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Nuts & Volts

EVERYTHING FOR ELECTRONICS!

August 2001
Vol. 22 No.8

Ultimate TV

Resistance is Futile ... or is it?

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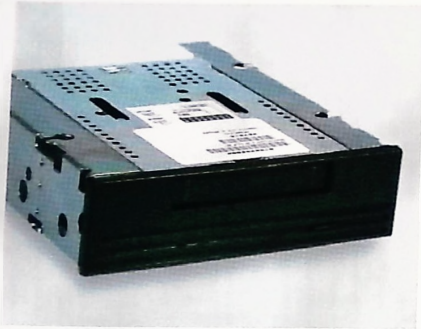

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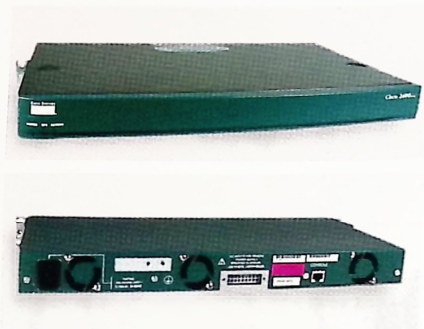

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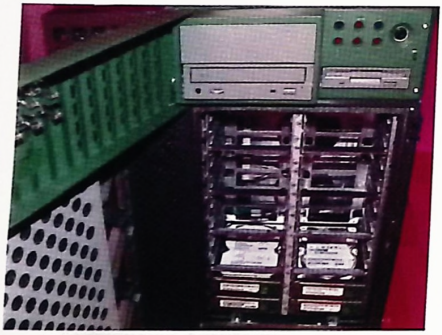

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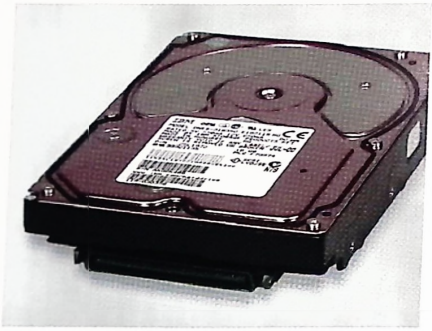

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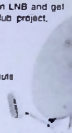

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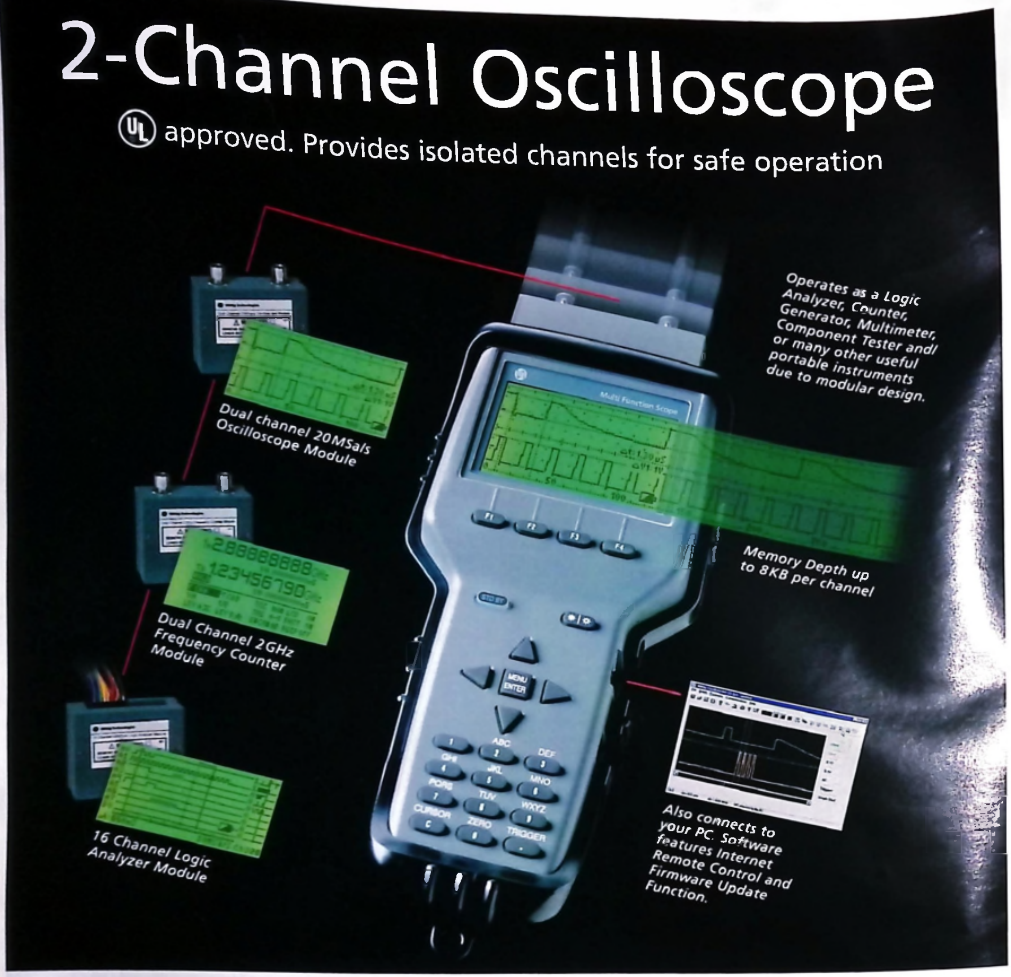

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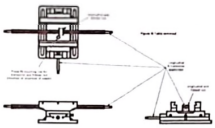

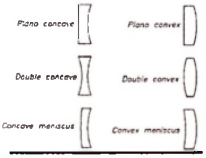

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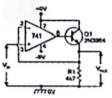


TechKnowledgey 2001

Events, Advances, and News From the Electronics World

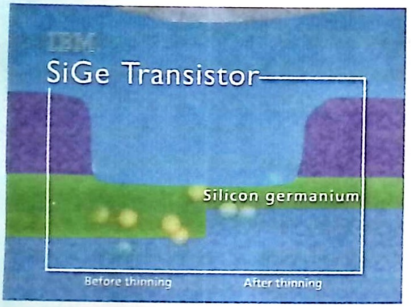
by Jeff Eckert

Advanced Technologies

Transistor Achieves 210 GHz Switching

IBM claims to have built the world's fastest silicon transistor, based on silicon germanium (SiGe) technology. The device is said to reach switching speeds of 210 GHz while drawing only 1 mA of current. This represents an 80 percent speed increase, and a 50 percent reduction in current usage, as compared to current designs. This is particularly interesting, because it was once believed that 200 GHz was the highest speed achievable in silicon.

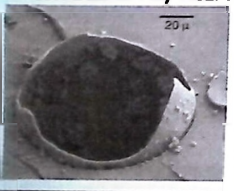
In general, higher speeds are achieved in transistors by shortening the path of the electrical flow through them. In standard silicon materials, the flow is in the horizontal direction, and shortening the path is relatively difficult. The new IBM device, called a heterojunction bipolar transistor, conducts electricity vertically.



IBM has achieved improved transistor performance by thinning the SiGe layer, effectively shortening the electrical path. Courtesy of International Business Machines Corporation.

Because it is much easier to thin the SiGe material height, thinning the SiGe layer results in significant performance improvements. Because transistors are the basic building blocks of semiconductor chips, this development should lead to new levels of performance in a variety of devices. SiGe chips can be built on existing manufacturing lines, which will allow the technology to be commercialized very quickly and at minimal cost. IBM predicts 100-GHz chips within the next two years.

Circuit Boards May Heal Themselves



Scanning electron microscope image of fracture surface. Courtesy of University of Illinois.

The US Air Force Office of Scientific Research is funding development of a new plastic resin formulation that automatically heals cracks caused by stress, corrosion, and aging. The material — being developed at the University of Illinois at Urbana-Champaign (**www.uluc.edu/**) with additional support from the University of Illinois Critical Research Institute — could extend the lifetime of printed circuit boards, where microcracks can lead to mechanical and electrical failures, as well as composite aircraft structures and other aerospace compositions.

Inspired by biological systems in which damage triggers a healing response, the new material contains microcapsules of repair material. When a structure begins to crack, the microcapsules rupture and release the healing agent into the damaged region via capillary action. As the agent contacts an embedded catalyst, the crack is closed through polymerization process. Although a commercially viable product is probably five to 10 years away, preliminary results are highly promising.

Computers and Networking

Computers and Video Cameras Perform Street Surveillance

Ignoring complaints from the American Civil Liberties Union and other privacy advocates, the city of Tampa, FL, has installed a system of CCTV cameras, computers, and face-recognition software that scans the faces of people who pass by, automatically comparing them to a database of approximately 30,000 criminal facial images stored in police databases. The installation is part of a $45 million revitalization project for Ybor City, the historic Cuban section of Tampa that is renowned for its restaurants, cigar factories, and spirited night life. The system is a product of **Visionics Corp. (www.visionics.com)** and its partner, Advanced Biometric Imaging L.L.C., which provides the FaceIt® image recognition program. Thirty-six cameras have been installed in strategic locations.

The authorities have assured the public that if a collected image does not match one of those in the criminal database, it is immediately discarded. This has not satisfied privacy advocates, however, who liken it to the famed George Orwell novel, 1984. "This is Big Brother actually implemented," said Jack Walters of the Tampa chapter of the American Civil Liberties Union. "I think this just opens the door to it being everywhere."

A similar system was used during the 2001 Super Bowl XXXV last January in Raymond James Stadium. During the game, it identified 19 people with outstanding arrest warrants, but all were for minor offenses, and no arrests were made. Even so, the concept is popular with law enforcement agencies and many politicians, so don't be surprised if it soon appears in your own home town. In addition to Ybor City, the technology is the underlying face recognition engine for CCTV operations in Iceland's Keflavik Airport and the UK's Newham Borough of London and Birmingham City Center. It is also used to enable mugshot/booking systems throughout the US, in casino applications, and in combating "hooliganism" in sporting events overseas. Now you have one more reason to wear a bag over your head.

Compaq Dumps Alpha Processor

In 1998, it was the future of Compaq's server product line. In 2001, it's headed for the dumpster of microprocessor technology, as **Compaq Computer Corp. (www.compaq.com)** prepares to phase out its 64-bit Alpha processor and substitute Intel's Itanium™ family in its server product line. In a multi-year deal that was announced late in June, Compaq will transfer key enterprise processor technology to Intel and consolidate its entire 64-bit server line on the Itanium architecture no later than 2004. During the transition, Compaq will continue development of one more Alpha processor, the EV7, and adventurous customers will be able to buy Alpha-based servers through 2003.

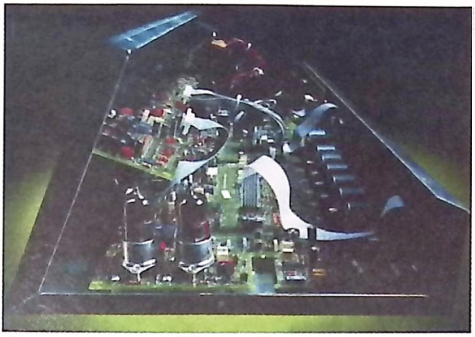
As the migration to Intel products progresses, Compaq's microprocessor engineers, compiler experts, and other related employees will be offered jobs with Intel. The company is also transferring significant Alpha microprocessor and compiler technology, tools, and resources to Intel, and it will immediately begin to port Tru64 UNIX, OpenVMS, and NonStop Kernel operating systems and development tools to the Itanium processor family.

According to a press release, "In one bold stroke, Compaq is extending its 10 years of leadership in 64-bit computing for the next decade and beyond." (This is similar to the bold stroke Napoleon took when he left Moscow in 1812.)

Circuits and Devices

Tube Amplifier Employs Digital Preprocessing

Guitar amplifiers tend to be of two varieties: old-fashioned tube-type and solid-state. Tube amps have the warm tone that musicians value, and you can overdrive the input without generating smoke. However, they are not particularly versatile in terms of sound output. But a new design from Fender, appearing in the form of the CyberTwin amplifier, maintains its analog output but employs digital signal processing between the instrument and the tube preamplifier. The result is an amp that offers a range of preset and user-configurable output settings that cannot be produced by conventional tube amps,



Fender's CyberTwin amplifier mixes DSP with tube amplification. Courtesy of Fender Musical Instruments Corp.

and yet generates amplification via two standard 12AX7 vacuum tubes. It offers 205 presets, including 85 rewritable. Players also can choose among 28 effects, 11 reverb types, and various other features. Output is 65 W driving twin 12-inch Celestion speakers. Fender claims that the CyberTwin will "change the way guitar players think about amplification from now on." For more information, visit **www.fender.com/cyber/**.

Low-Cost Infrared Thermometer

Falling into the category of "things you may not need but can afford to buy for fun" is the OS540 noncontact infrared thermometer from **Omega Engineering (www.omega.com)**. It is a portable instrument that is designed for electrical and electronic applications, automotive maintenance, screen printing (to measure ink and dryer temperatures), in-process temperature measurement, etc. The hand-held device offers laser sighting with a circle or dot for accurate measurement. Its operating range is -20 to +420C (0 to 788F), with resolution of 1C/1F. Response time is 500 ms, and accuracy is rated at ±3 percent. Best of all, it's only $85.00 list.

The OS540 infrared thermometer. Courtesy of Omega Engineering.

Industry and the Profession

Research Group Funded for X-Ray Crystallography Project

A Cornell University-led research group comprising 25 faculty members from six institutions has been awarded a $19.6 million, five-year grant by the National Institutes of Health to build a structural biology research facility at Argonne National Laboratory's Advanced Photon Source **(APS, www.aps.anl.gov/aps.php)**. The amount of the first year's grant is $4.6 million. The scientists believe that the results of their research will have an important impact on human health care, pharmaceutical development, and biotechnology. The goal is to apply the techniques of x-ray crystallography (a process that involves firing a beam of x-rays through a crystallized protein sample to determine its structure) to the causes and treatments of human disease, including cancers and diseases of the immune system. Areas that will be investigated include cell-cycle regulation, DNA transcription, initiation and regulation, the structure and function of viruses and enzymes, and protein folding.

The research group is called the Northeastern Collaborative Access Team (NE-CAT) and consists of faculty from Cornell, Columbia University, Harvard University, Memorial Sloan-Kettering Cancer Center, Rockefeller University, and Yale University. The APS is a third-generation particle storage ring built by the Department of Energy at a cost of nearly $1 billion and is one of the most powerful x-ray sources in the world. The NE-CAT facility is just one of 34 being developed at APS through scientific collaborations and one of only a handful to focus on biological research. In addition to the NIH funding, the NE-CAT project also will receive $6.6 million from member institutions and $1.5 million from the APS. **NV**

Microsoft UltimateTV

UltimateTV™ from Microsoft

by Ed Driscoll

The annual Consumer Electronics Show (CES) in Las Vegas is always a zoo. Hundreds of thousands of people wander around the vast, cavernous, aircraft hangar-like rooms of the Las Vegas Convention Center in a fluorescent subwoofer surround sound hard-wired zombiefied daze, looking for the next killer app, the next great electronic product, or at least something new and out of the ordinary.

Some years, they get lucky. But the consensus of many of them is that the 2001 CES was slim pickings and that the only standout product at this year's CES was Microsoft's UltimateTV set-top box.

It's the Swiss army knife of set-top boxes, combining two DirecTV satellite TV tuners, WebTV Internet access, interactive TV, picture-in-picture, and a digital video recorder (DVR) into one box.

And that's a lot of stuff! But for any one of the nine million people who has a DirecTV satellite dish, it's a product that is long overdue. With 300 or more channels of programming on 24 hours a day, there are bound to be shows on at inconvenient times or two favorite shows on at once.

How Microsoft Got Into the Set-Top Box Business

UltimateTV is the end result of a joint venture involving Microsoft, DirecTV, Sony, and RCA. DirecTV supplies the programming, Sony and RCA both make the UltimateTV hardware and, of course, Microsoft provides the software. We tested RCA's version — the DWD490RE — but its Sony unit counterpart is functionally identical. At $399.00 suggested retail, it's certainly cheaper than buying a Replay TV or TiVo and a WebTV Plus box, and it adds Web-based interactivity to DirecTV. Also, putting three units into one set-top box adds much more flexibility than using separate components, and frees up that many inputs on an A/V receiver.

The unit combines lessons learned from their set-top box for Dish Network, for whom Microsoft created a first generation DVR product, which Mark Mullen, the Senior Director of Brand/User Experience for Microsoft UltimateTV says "was really just a combination of WebTV and a DVR." "And there was significantly less integration between them. There was only one tuner. I believe the recording capacity was 12 hours of content." And yet, even with those shortcomings, Mullen believes this is the best selling DVR box out there, with over a 150,000 of them in Dish customers' homes.

And DVR is a very big upgrade over VCR. While most DirecTV set-top boxes allow for easy programming of a VCR, tapes — even SVHS — aren't as sharp as the satellite's digital picture quality, and they wear out when taped over every day. Also, until now, a separate set-top box was required to tape one show when watching another. UltimateTV replaces all of that with the digital video recorder: a hard disk drive as VCR.

Curiously, UltimateTV is not the first DVR that's designed to work with DirecTV. That product would be the TiVo DirecTV receiver, which debuted last fall. Does DirecTV worry about having two competing products available for users? Bob Marsocci, DirecTV's director of communications, says it's just the opposite, and that the firm's goal is to offer their customers as many choices and options as possible. "If you look at us, we're sort of like an aggregator of brands and services.

Using HBO and Showtime as an example, these are two competing premium movie services. But obviously, you can get one, you can get both, or you can choose obviously not to subscribe to either of them, if you're a DirecTV customer. And we carry that philosophy over to the new products and services that we've been rolling out since last fall."

What's in the Box?

The DWxD490RE records approximately 35 hours on its hard drive. DirecTV is known for its sharp picture, especially when compared to its ghosty, noisy, downright lousy cable counterpart. With the DWD490RE, I couldn't tell the difference between the digital satellite picture, and a digitally recorded picture. The disappointing feeling of watching inferior videotape is quickly replaced by the feeling of watching a live TV show that can be paused, rewound, and then fast-forwarded!

The DWD490RE's remote control resembles the standard RCA DirecTV remote, but it includes a few extra buttons to operate the features that UltimateTV adds. One of the most useful buttons is the one that allows for a 15-second advance, great to zap commercials on a recorded show. It has a companion button, which does the reverse, but for recorded and live shows. Want to have your own instant replay of a touchdown? Miss a line of dialogue? Zap! — just rewind!

Going Interactive

Just as DirecTV has the TiVo/DirecTV box, which competes for DirecTV customers with UltimateTV in the DVR area, DirecTV also has two tiers of interactive service. Their baseline service, using technology by Wink Communications, is offered free to anybody with an entry-level Sony or RCA box equipped with the appropriate circuitry. Wink adds some simple interactivity to DirecTV, basically, information on demand.

In contrast, the UltimateTV box allows for the much more extensive interactive capabilities of Microsoft's WebTV platform. "The entire NCAA basketball tournament has been broadcast as an enhanced television program from CBS," Mullen says. Viewing the games on an UltimateTV box, "When the tournament was in full swing, I could look at the stats from any of the other games, whether they were the ones currently being broadcast or not. I could get the player rosters, I could get the player bios. I could get the tournament standings, which in the case of the NCAA tournament, as you know, includes whoever won on the other side of the ladder. And you can get the up-to-the-minute, even up-to-the-second, news and information on the tournament, straight off that one screen, while you're watching one of the games in progress."

Mullen describes the experience as an "illustration of what interactive TV is today, and what it can be, as it moves forward. By the way, it does work if you record it, so that all of the Interactive

enhancements are included with the recorded programming, as well as the live."

The Monthly Fees

Of course, that digital recording and interactive TV doesn't come for free. Like everything offered by DirecTV, there's a cost. The monthly fee for UltimateTV is $9.95, which includes three hours of Internet access. (Microsoft assumes that most users of the box will not be using it as their primary Internet source, unlike users of WebTV.) The same service with unlimited 'Net access is $29.95, or $14.95, if an existing ISP account is used. Of course, this is in addition to an existing DirecTV monthly fee, which varies based on the packages of channels, and other options chosen.

Besides three hours of Internet access, what do you get for that $9.95 that's added to your monthly DirecTV fee? Mullen says that the service "includes the live TV controls, digital video recording (35 hours), all of the 14-day searchable program guide, interactive TV capability, and three hours of Internet connect time, as well as six email accounts, and automatic software upgrades."

Mullen says that the three hours a month of Internet service included in the $9.95 package was carefully chosen, because for "most of the people who buy UltimateTV, this is not going to be their primary point of Internet access." However, for those who want it, unlimited Internet access is available.

Is Resistance Futile?

Will there be much resistance to UltimateTV's fee arrangement? One very smart decision on Microsoft's part was to aim their product towards DirecTV users, rather than the larger pool of cable and over-the-air customers. DirecTV users are used to paying extra to get the exact television package that they want, whether it's the NFL Sunday Ticket Package, or a selection of family-oriented channels, or a selection of movie channels.

Mullen says, "we believe that there actually is value in this as a subscription, and that we will continue to add value, over time, the way that we have with the WebTV service, where there are upgrades and feature improvements and enhancements sent down two or three times a year. If you bought a WebTV box in 1996, you can be using the same box today, and it's doing way more stuff than it ever was doing at the time that you bought it."

The Ghosts in the Machine

While Microsoft has dubbed their product UltimateTV, even with a name like that, there are going to be a few problems and concerns, each of which may or may not be trivial, depending upon expectations. First, if you wish to use your own ISP with the box, not all of them are compatible. For example, AOL, Compuserve, and Prodigy are not, but MSN (naturally), Mindspring, and Earthlink are, as are most high-speed connections, like @Home.

Mullen says that the ISPs that aren't compatible are non-standard in the way that they do the handshaking protocols. "I think it's the IMAPI standard. So they don't do some standard stuff, so we can't go through their dial-up to get to our service. It's not a policy thing, it's not a competitive thing, it is the fact they've chosen not to support the standard protocols."

Whatever ISP is used to connect the Internet, it will probably be on the UltimateTV box's 56k modem. But when Microsoft debuted UltimateTV at CES, the units were all connected to high-speed Internet access via a dongle that connected an RJ-45 cable to the USB port built into the UltimateTV box, which allowed the WebTV component of the box to fly. It's unfortunate that this dongle couldn't have been included with the unit, or be immediately available as an accessory. Any long-time cable modem or DSL user will be thrilled to junk UltimateTV's comparatively poky dial-up modem for a high-speed connection. This feature is due to be commercially available by fall 2001.

The unit also lacks an HDTV tuner. While HDTV hasn't taken off the way that its backers had forecast, if it does, this could speed up the obsolescence of this generation of UltimateTV box. And because it would involve digitizing an analog signal, which would add to the cost and complexity of the signal, the unit can't record regular (off-the-air, or cable) television, typically local channels, unless those local channels are subscribed to via DirecTV — a real loss.

But these are minor compared to the fairly nasty bug discovered in Microsoft's UltimateTV software soon after the boxes hit the streets in March. Microsoft said in a statement, that "if a subscriber deletes a recorded program while in

UltimateTV™
from Microsoft

UltimateTV™
from Microsoft

'pause' mode, the listing of this recorded program disappears from the My Shows listing, but the recorded content is not actually deleted from the hard drive, thus the continued diminished storage space on the hard drive." A patch is currently available by calling Microsoft's technical support line. And Microsoft plans to include it in their first round of regularly scheduled software upgrades, which was planned for May of 2001.

This software upgrade will also fix another feature that's much more of an annoyance than a bug. The UltimateTV box overwrites existing recorded material when you run out of space, but you can't choose what it will overwrite. At the moment, programs will scroll off, as new shows are added. So while waiting for this patch, copy any show that's a keeper to videotape before it's recorded over on the hard drive.

Hopefully, it's safe to assume that the one big bug in the unit will be fixed by Microsoft's software patch (and it better be, or Microsoft's rep in this new industry will be lower than whale droppings).

If that's the case, then Microsoft's UltimateTV at least in the form of the RCA DWD490RE set-top box that we tested, will come pretty damn close to living up to its name. **NV**

PRODUCT SPECS

RCA DWD490RE DirecTV Receiver with UltimateTV Service

Product Price (MSRP): $399.00
(DirecTV satellite dish also needed. RCA's DS4290RE packages the DWD490RE with a dish, for $449.00.)
Cost of service: $9.95 for UltimateTV service in addition to existing DirecTV fees. Monthly fee includes three hours of WebTV access.
$29.95 for UltimateTV service and unlimited WebTV access,($14.95 if existing ISP is used).
A/V in/outputs:
Front panel: Audio/Video/Mic Input
Back panel: Dual Audio/Video RCA Outputs
Channel 3/4 RF Output
Two DirecTV RF Inputs
One Antenna/cable TV RF input
One set of S-Video input and output jacks
Digital Audio Output via Toslink jack. PCM audio, unless show is broadcast in Dolby Digital
VCR control output (to enclosed cable with mini-plug and IR transmitter)
Hard drive size: Records up to 35 hours of programming
Other in/outputs:
One telephone jack for both Internet and DirecTV data
Two USB ports for planned high-speed connection
Dimensions: 17"W, 11"D, 3"H
Weight: 16.20 lbs
Modem: V.90 (56k-capable) modem
Documentation: Detailed full color setup and user guides
Web site: http://www.rca.com/product/view modellist/browseproduct/1,1323,CI100073,00.html

FABULOUS MOTION SYSTEM, Asymtek 403G series. The Automove® 403G is a highly configurable, automatic fluid dispensing system capable of handling a full range of dispensing applications. Wherever hand-held dispensers are currently used, automating with the 403G system will increase both accuracy and throughput. Of course the system can be configured for many other motion automation applications as well. Your imagination is the key. The system can be programmed to dispense dots or continuous lines precisely and consistently using a wide variety of fluids. This flexibility makes it ideal for applications ranging from surface mount electronics to form-in-place gasketing. The system offers several standard features. At speeds of up to 508 mm/sec (20 in /s), it provides ± 0.05 mm (0.001 in.) resolution with a teach accuracy of 0.025 mm (0.001 in.). It is a gantry configuration with a 457 x 457 mm (18 x 18 in.) work area. Overall size: 36"W x 28"D x 20"H. Once programmed with a personal computer, the 403G stores up to 10 separate programs in onboard memory. Features: • Programmable speeds up to 508 mm/s (20 in./s) perfect for fast, short, repetitive moves required in automated assembly. • Semi-automatic part skew allowance corrects for workpiece misalignment. • Easy-to-use, flexible, Fluidmove® software for quick program creation is available from the manufacturer. (Not supplied). • Eight extra inputs and outputs provide interface to I/O-triggered devices for further automation. • Multi-pin programs can be stored in onboard memory allowing computer-free operation in a production environment. Unit is used and in excellent condition. Ships via truck. See www.asymtek.com for info. **Reg. Price >$10K, Special Asymtek 403G.....$2895**

FLEXIBLE SHAFT with LEAD SCREW and "NUT" New, 18" long flex shaft is enclosed in a 3/8" OD protective sheath. One end "Plugs" into a right angle drive which outputs the flex rotation by turning at a 1/2" diam. x 7"L, 10 TPI lead screw upon which rides a 1" x1" 2"L "nut / carriage" with two 1/4 x 20 threaded holes spaced 1" apart on the long axis. Flex shafts have a 0.14" x 0.14" square drive end. You receive two complete assemblies one with a nylon carriage and one with a steel carriage. They were originally designed to move power seats. We do not know what car. Heavy duty construction. A very interesting device. **FLEX-PAIR.....$39 / set.**

BOGEN MODEL 3232 TILT MOUNT, Nice tilt-an made mount provides +/- 90 degrees of motion. Solid cast alum. construction with black powder coat finish. Industry std reversible 1/4" x 20 or 3/8" male top mount with cork pad. Tilt base is attached to a removable 3.5"L x 2.5"W x 0.5" thick, black anodized aluminum plate via a 3/8" bolt **BOGEN-3232.....$10ea.**

WEATHERPROOF LIPSTICK CAMERA B&W, industrial strength, solid machined housing. Sleek black anodized O-Ring sealed, BRASS housing. Adjustable mount included. Specs: 1/3" CCD. 400 Lines resolution. 0.05 Lux sensitivity. AGC. Auto Shutter. Operates on 12VDC @200ma, 4mm, 78° FOV lens. A real glass lens. NTSC video out. Superior construction. SENSITIVE to IR. Ultra small Size only 1.25" diam. x 2" long. With 60 ft. cable. Great for general outdoor use. **NEW, GM300K-N.....$99**

NEW! 6.8" LCD COLOR, TFT, ACTIVE MATRIX DISPLAY, A huge 22sq. inch VIEWABLE AREA, Super Deal. 2.8X the VIEWING AREA of a 4" panel and 1.5X a 5.6" WOW! We wish you could see the color saturation and resolution of this superior LCD display, it is fantastic. Excellent contrast ratio, high quality, full color images are comparable to a CRT. Perfect as a portable, general purpose color monitor for standard NTSC ca'or or B&W video systems. Fully compatible with all our cameras as well as Camcorders, VCR's, DVD's etc. OEM "component" style unit has no outer cabinet. Designed to be installed in YOUR housing via four mounting tabs as shown. Specs: Resolution: 115PH x 234V, 270K Pixels. Viewing angle: Top 10°, Down 30°, Left 45°, Right 45°. Brightness: 300 nit. Size: W x H x D: 6mm/Frl, 157.2 x 122.6 x 8.0, 6.2" x 4.83" x 1.1". Weight: 1gm /oz / 280 gm, 10oz. Supplied with 30" input cable. Video input via BNC jack. 12VDC input via a standard barrel connector. Reg/sided 12VDC @700mA power adapter included. **BRAND NEW, FIRST QUALITY, GM-TFT6B.....$169ea.**

NEW, LINEAR BALL SLIDES from DCI, Three model's available. The large is 6"L x 2.6"W x 1"H with 4" of travel. The medium is 5"L x 2.6"W x 1"H with 3" of travel. The small is 1.75"W x 1.75"L x 0.75"H with 1" of travel with a removable spring return for use against a micrometer or similar. Features common to all include: Solid machined aluminum with anodized construction, hardened steel ways. Slides are usable in any position and can carry heavy loads. Over 100lbs for the large and medium and 25lbs for the small. Straight line accuracy of 0.00008"/inch of travel. All are new. Limited quantity. **DCI-LONG.....$79ea. DCI-MEDIUM.....$49ea. DCI-SHORT.....$45ea.**

STEPPER DRIVEN LINEAR SLIDE is STURDY and COMPACT. Techno-tool based, heavy duty 1.5" wide, aluminum and steel, dual rail. Drive is via a toothed belt, powered by a SLO-SYN M061-LF-504, 1.25V @3.8A stepper motor with 200 steps per rev and 60 oz. in. hold. The slides incorporate super quality, recirculating ball bearings. Size of slider is 3" x 3" x 1/2" thick with mounting plate. Limited quantity. Unit is mounted on a 1/4" thick, black anodized alum. plate. All have been carefully removed for precision optical equipment. Travel: 11.5", Rail Length: 16", Weight: 7lbs., Overall Size: 16"L x 4"W x 6.5"H. Very Id. Qty. **ISELMTR-SHORT.....$149ea.**

PULNIX, INDUSTRIAL 1/2", COLOR CCD CAMERA, type TMC-7 with Pentax Lens. Built for no compromise applications.
Specs: 1/2" CCD. 460 Lines resolution. 768H x 494V Pixels. 2 Lux sensitivity @ f1.4. Auto/Manual AGC. Auto/Manual Shutter from 1/60 to 1/10,000 remotely controllable via a pin connector (not included). Auto/Manual white balance. Manual gain and hue control from outside the camera. Comp/memory color filter. Operates on 12VDC @170mA. Power supply included. Also includes a high quality Pentax, 16mm f1.4 lens. Areal glass lens. Standard NTSC video out on BNC connector. Y/C (S-Video) output also available on 12 pin connector supplied. Superior construction. Compact size only: 1.6"W x 1.25"H x 5.5" long. Perfect for use in process monitoring, surveillance, medical and microscopy. Excellent condition, removed from inspection systems. Regular price $600 **SPECIAL, PULNIX, TMC-7.....$149ea. or 2 for $249**

SPECIAL PRICE, 350MHz, TEKTRONIX 2467, MICRO CHANNEL PLATE CRT! 4 Channels, 500ps per div. in normal roam light.
Displays intermittent variations as they happen. Captures the slowest one shot events with 4ns per division a 100 fold increase in the vessel writing rate over conventional CRT. Features 1 ns rise time, 500ps/Div time base, 2mV/Div vertical sensitivity at 350MHz, 20ps time interval resolution, 1Mohm / 50 ohm input, 500MHz bigger bandwidth, four channels. On-screen waveform cursors provide vert cal & horizontal scale factors, trigger level, voltage, time, freq., phase, rat o values and mode indication. With 2 probes, pouch and manual. EX. cond. 90 day warranty. **New..$12K Now SPECIAL, TEK 2467.....$2495.**

NEW! 0.01 Lux, COLOR NIGHT VISION CAMERA! FANTASTIC LOW LIGHT PERFORMANCE. Exclusive ON SCREEN, menu driven setup of all camera parameters. NEW, STATE of the ART, GMV-35KOSD,
Perfect for covert, military & scientific applications that must be color. Unbelievable 0.01Lux @ f1.2 performance is enhanced through low speed electronic shuttering, digital frame integration and advanced DSP. Auto sensitivity mode starts as it becomes dark. 24 hour surveillance is possible with the optional f1.2 lens shown below. Specs include: Shutter speed data or manual 1/60 to 1/120,000, 60dB S/N ratio!, 154dB Smear rejection, AGC gain 0 dB to 18 dB is set beyond the noise level of CCD. Digital gain 0dB to 12dB. Digital zoom continuous from up to 2X in 0.1X steps. Masking mode allows hiding 4 programmable zones for privacy protection. Camera on screen name. Choose you own name for the camera and display it on monitor for easy identification. White balance modes: Auto tracking, one push or selection from 3200K, 4800K, 5600K, 7800K, and "double white balance" independent white balance circuit for both bright and dark zone, ma mtains correct white balance even with combined indoor and outdoor lighting. Programmable 48 zone back light compensation mode for difficult lighting situation. Negative mode for negative film imaging. Mirror image and up/down select on for rear view and camera mounted upside down. Seven Gain/Shutter modes are user selectable. Normal, X2, X4, X8, X16, X24, X32, X64. These provide frame rates of 60, 30, 15, 8, 4, 3, 2, and 1 per second. Alum. housing, dual 1/4x20 mtg. Specs: 1/2" CCD, 811H x 508V, with 412K pixels, 470 Lines, 12VDC ±1V @250mA, Std. video out on BNC. Std S-Video out on 4Pin connector. Size: 2"H x 2"W x 4.5" long. Regulated power adapter included. Use standard c-mount lens not included. **SPECIAL, GMV-35KOSD.....$429ea. High performance lens, 12mm, f1.2...$69ea.**

SUPER SLUETH, SPY BORESCOPE, Actually a doctor would call it an otoscope or boroscope. Super high quality medical grade, stainless, construction. Direct view eyepiece with a 6.5" long, 5mm diam. tube. Objective end optic is at a 30 degree angle for easy viewing of surrounding area. 7.5mm diam. external light port. Very limited quantity. **Hospital Price....$800ea. SPECIAL.....$229ea. Please see web for additional models.**

A COOL COLOR CAMERA, "The ROVING EYE CAM" with Ultra Compact, 12X ZOOM, PAN and TILT, AUTO IRIS and AUTO FOCUS to boot!
A super quality color camera, part of a high end system from PictureTel. Each unit consists of a camera head attached to a base PC board. The attachment is via a moveable mount. There are two tiny stepper drives which create the pan and tilt motion. The tilt stepper is mounted to the PC board. The pan stepper is unmounted and attaches to the side on your base or enclosure. The camera is controllable via serial commands however we have no info on how to do it. Anyone who can tell us can have some free cameras. The camera module specs: 400+ lines @ 1lux, the power required is 12VDC @ 500mA. size of head is 5.5" diam. x 3.2"h. The attached PCB is 3W" x 4L" x 1.3"H. Zoom is controlled via the serial port. No info. Composite video output. We think it has Y/C also. Order now, the price goes up when we get the serial commands. Removed and individually tested for auto focus, auto iris, P&T and video output. Very high quality. **SPECIAL, R2D2....$99ea. or 5 for $375, NTSC or PAL avail.**

NEW, lower cost, High quality, MINI BOARD CAM, w/audio 1/3" CCD. 420 Lines Res., 0.3 Lux sens., AGC, Auto Shutter. Pwr from 9 to 12VDC @100mA, 266k PIXELS, Std mount, 3.7mm, 92° FOV lens. A real glass lens. Auto shutter from 1/60 to 1/100,000 sec. Focus from 10mm to infinity. Std. NTSC video out. 1/2 ounce! SENSITIVE to IR. Size Std 1.25"sq. x 1"d. Connections via a 6" pigtail with PC board connector. **SPECIAL, GM-1000B-STD.....$45ea.**

NEW! 6.8" LCD COLOR, TFT, ACTIVE MATRIX DISPLAY, A huge 22sq. inch VIEWABLE AREA, Super Deal. 2.8X the VIEWING AREA of a 4" panel and 1.5X a 5.6" WOW! We wish you could see the color saturation and resolution of this superior LCD display, it is fantastic. Excellent contrast ratio, high quality, full color images are comparable to a CRT. Perfect as a portable, general purpose color monitor for standard NTSC ca'or or B&W video systems. Fully compatible with all our cameras as well as Camcorders, VCR's, DVD's etc. OEM "component" style unit has no outer cabinet. Designed to be installed in YOUR housing via four mounting tabs as shown. Specs: Resolution: 115PH x 234V, 270K Pixels. Viewing angle: Top 10°, Down 30°, Left 45°, Right 45°. Brightness: 300 nit. Size: W x H x D: 6mm/Frl, 157.2 x 122.6 x 8.0, 6.2" x 4.83" x 1.1". Weight: 1gm /oz / 280 gm, 10oz. Supplied with 30" input cable. Video input via BNC jack. 12VDC input via a standard barrel connector. Reg/sided 12VDC @700mA power adapter included. **BRAND NEW, FIRST QUALITY, GM-TFT6B.....$169ea.**

CARL ZEISS, S-PLANAR LENS, GCA type 37, 1.4/75, M1:5nA=0.30,
A fantastic lens with a current replacement cost of $20K. Extremely flat field. From Photo-Lithography system, excellent condition. **ZEISS-PLANAR.....$495**

IEE, 1X20 VF DISPLAY MODULE
New, model 503601-82-02C series The module includes the VFD, microcomputer and driver. Connects directly to the system bus via 8 bit, TTL compat ble input. Display up to 20 dot matrix, 5 x 7 characters (96 character U.S. ASCII-7), 5mm H x 3.5mm W with cursor. Display color is green at 505nm. Brightness is 170fL. Weight: 4 oz. Size: 6.631 x 2.72"h x 0.6" thick. Power required is 5VDC@ 386mA. Perfect for any high visibility display requirement. With data. **SPECIAL IEE-VFD20.....$12ea. or 4 for $39**

SUPER, MINI C-MOUNT CAMERAS, Super sensitive, GM410 or the general purpose GM412,
The GM-412 (bottom) specs B&W, size: 1.5"sq. X 2.4"L. 250,000 Pixels. 380 Lines Resolution. Sensitivity 0.3 Lux. The GM410 (top) specs: size only 1.5" SQ. x 1.6"L. >270,000 Pixels. 410 Lines Res., Sens. 0.05 LUX., Both cameras are 1/3" CCD with AGC & Electronic shutter. 12V @110mA power. NTSC with IR SENSITIVE, BNC video out. Both use std. DC pwr jack. Aluminum housings with duel threaded top and bottom mounting. True performance not hype! These cameras will outperform ANY camera in this magazine. Multi-lens options are available to expand their superior performance. **GM412, less lens..$99, GM410, less lens..$149**

16 x 2, LCD DISPLAY and KEYBOARD COMBO, NICE!
A Densitron 2162A-01 CCD module, incl backlight with 18 key elastomeric keypad arranged in a 4 x5 matrix. The right most 12 keys are labeled like a telephone pad while the 6 leftmost keys a labeled with Up/Down and Left /right cursor symbols as well as a return and function key. I/O is via a 3" long, 24 pin, std. IDC ribbon cable. Data sheet for a std. 2162A LCD module and keyboard cable pinout included. LCD is a standard 16 x 2 arrangement of 5 x 7 dot matrix characters. 2.96mmW x 5.56mmH with cursor. TN type with top viewing. On board industry standard Hitachi 44780 driver with 8 bit parallel interface. Overall board size: 6.4"L x 2.5"H x 0.6"D. Viewing area: 62mmW x 16.2mmH. Will really make your project look pro! **Brand New, with data, LCDKBD-2162.....$5.00ea, or 10 for $4.50ea. or 100 for $3.50ea.**

NEW & IMPROVED, 0.003Lux, UNDERWATER B&W CAMERA, 16X MORE SENSITIVE. Now with 12" INTERNAL INFRA-RED LED's! Sleek black anodized, BRASS housing. O-Ring sealed & WATERPROOF down to 60feet. Adjustable mount included. Specs: 1/3" CCD, 400 Lines res., super 0.003 Lux sensitivity, AGC, Auto Shutter. 12VDC @200mA, 4mm, 78° FOV lens. A real glass lens. NTSC video out. Superior construction. Ultra small Size only: 1.25"diam. X 2" long. With 60 ft. cable. Perfect as a remote area inspection camera. TWELVE super white LED's! **GM-400K-12LED.....$229ea.**

NEW and IMPROVED, COLOR (down to 60 ft.) UNDERWATER, now with 12, Built-in WHITE LIGHT LED'S, Sleek black anodized, BRASS, housing. O-Ring sealed & WATERPROOF. Adjustable mount incl. Specs: 1/4" CCD, 350 lines res., 0.5 Lux sensitivity, AGC, Auto Shutter. 12VDC @200ma, 4mm, 78° FOV lens. A real glass lens. NTSC video out. Superior construction. Ultra small Size only: 1.25"diam. X 2" long. With 60 ft. cable. Perfect as a remote area inspection camera. TWELVE super white LED's! **GM-400K-12LED.....$229ea.**

DAYLIGHT/LOW LIGHT MINI CAM & A/I LENS, For down hill dusk applications. Rugged diam. housing, dual mtg. holes. 1/3" CCD, 420 lines res., 0.1 Lux sens., AGC, 12VDC @120mA. Take full advantage of camera sensitivity with super, 4mm, f1.4, 78° FOV Auto Iris lens included. BNC video out. 50mm sq. X 65mmL. With pwr. adapt. **GM-510A/I.....$179 or 2/$349**

B&W QUAD PROCESOR, The GM4-BQ is an unbeatable value. Four camera inputs with loop through. Full screen image, REAL TIME display, high resolution 960 x480, brightness adj. for each chan. Alarm time (1-20 sec.) 4 alarm inputs. Auto Sequencing mode with adj. dwell 1-4 sec. Quality video processing. Specs: •4 video inputs, •1 monitor out and VCR in/out, •4 alarm inputs •Buzzer •2 Alarm Out •Dim: 239 x166 x55 mm. **GM4-BQ QUAD.....$179**

ULTRA RESOLUTION & HIGH SENSITIVITY, SCIENTIFIC QUALITY for demanding applications. Type GM-6000, offers 410K pixels, 570 Lines resolution, < 0.1 LUX sensitivity, >45db s/N with AGC off. Access all operating parameters, outside the camera! C or CS mount. Adjustable shutter speed from 1/60 to 1/100,000sec, BLC on/off, AGC on/off, gain auto/off, Auto iris selectable, DC/Video with level control, external/internal sync. 24VAC powered, adapter included. Video out on BNC. Industrial quality metal housing. Just the thing for scientific or low light. **SPECIAL, GM6000.....$199ea.**

reader FeedBack

Dear Nuts & Volts:

In the latest issue, I see MgB2 and other misrepresentations. Surely you don't want to mislead the unwashed multitude! Why don't you use the normal conventional internationally accepted MgB_2? (Unfortunately, my email system doesn't allow for super and sub scripts, so this is the closest I can do.) You certainly know what I mean though.

The numerical value denoting the number of atoms of a particular element in a compound is represented by a subscript.

Calcium Carbonate is $CaCO_3$, not CaCO3. etc. Aitch tu oh is water! Two atoms of hydrogen and one of oxygen make up the water molecule.

Leonard E. Herzmark, P. E.
Tucson, AZ

Dear Nuts & Volts:

I was pleasantly surprised to see my bicycle — Behemoth — on page 89 of your July '01 issue ... after 17 years of being pedaled around the US, accompanying me on speaking tours via diesel mothership, and gathering fiberglass dust in my lab while the Microships are being built. It has at last found the perfect home.

As author Ed Driscoll, Jr. pointed out, The Computer Museum History Center is truly an amazing place, worth a pilgrimage by any devoted techie.

I would like to make one minor correction to the story and also pass along a URL for more information. First, my company is Nomadic Research Labs (not Pneumatic, tires and deployable landing gear notwithstanding). Second, readers can find loads of tech detail on the bikes, as well as our new Microship project at http://www.microship.com.

Steven K. Roberts
Nomadic Research Labs

Dear Nuts & Volts:

I strongly agree with the letter from Analog Systems Engineer; Yahoo! Dallas.

Frankly, I was reluctant to respond by email for fear of harassment by an offended hacker! This group of individuals is usually the first to complain when their "rights" are infringed upon. They never seem to care about the damage they inflict with their less than harmless activities. You do your readers a great service by printing such a letter.

Michael Herman
New York, NY

Dear Nuts & Volts:

Part 1 of the article "Small Logic Gates Spawn Big Dreams" had significant errors in the diagrams and tables. I didn't bother writing because I supposed that everyone caught them and I expected to see something about it in the June issue of *Nuts & Volts*. I also assumed that Part 2 of the series would be more closely scrutinized; however, I had to stop reading it after the first page to write this email.

The very first truth table (for the half adder) is just wrong, and the second table has an error. On a subjective issue, a half adder is much more succinctly described as ...

SUM = A xor B
CARRY = A and B

This requires only two logic gates and is very easy to follow, as opposed to the handful used in the article which requires much more thought to interpret.

The author did explain that the goal of the article was on how to use the functions as opposed to how they work. With that in mind, showing how two half-adders (in block diagram form) are wired together to make a full adder is much more instructive than a logic schematic. This is an important point which is not mentioned in the article and is not plainly obvious in the schematic.

Enough of my lecture. I am a new subscriber, and this is only my third issue of *Nuts & Volts*. I understand and expect to see mistakes in technical journals. I just hope to see less of them in the future.

I have one last idea. It would be interesting if each article had a brief author bio at the end. A short backgrounder to let us know where the article is coming from.

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News Bytes

BTR TO LAUNCH LARGEST HOBBY ROBOTIC SITE

Robotzone.com, a division of Brian Thomas Robotics (BTR), will be launched September 28th, 2001. BTR promises that it will be the largest hobby robotic site on the net.

Robotzone's main objective is to offer robot hobbyist parts and supplies never offered before. Just a few examples are gears (48 and 32 pitch) and sprockets that mount directly to hobby servos, servo gearboxes, wheel adaptors, wheels, high power servos (250+ lbs. of thrust), servo mounts, hobby servo encoders, sensors, all types of linkages, and thousands of more products.

Not only will they offer parts, they are also launching an entire line of robot kits. These kits will range in price from $50.00 to $2,000.00. They will also be offering free shipping for the first month that the website is online! Be sure to check them out this coming September and also check out their latest site — www.ServoCity.com — for great pricing on high-tech servos and parts.

INCREASE YOUR INTERNET SAFETY AND PRIVACY WITH PC FLANK

PC Flank (http://www.pcflank.com/) is a new, free Internet resource that gives users the tools needed to protect their computers from Internet viruses, as well as Trojan horse and backdoor attacks.

PC Flank's testing facility lets you determine if your system is vulnerable to virus and Trojan attacks. In less than five minutes, PC Flank will produce a report on the quality of your system's security, plus concrete recommendations for how you can make your surfing safer. The test will determine if you already have a known Trojan infection that is sending your valuable information to third parties without your knowledge. It will test your computer's ports and determine if they are accessible to hackers. It will even tell you how much of your personal information your web browser is providing to outsiders, and make recommendations on how you might adjust browser settings to increase your privacy.

PC Flank's "Ask the Experts" web pages give you several tools for determining how safe your system is, and how to increase your security. There are security experts who will answer your security questions for free. For routine concerns, there is a Frequently Asked Questions (FAQ) page that lists the most common questions — and insightful answers — about computer security. You can view recently asked questions, a security tip of the day, and a glossary of Internet safety and security terms.

The online forum is a growing community of Internet users who are interested in discussing Internet security issues. You can post questions and answers to discussions about which anti-virus software is most effective, which firewalls keep you safe, and which anti-Trojan software is able to effectively keep hackers from stealing your private information.

PC Flank's virus information database lets you learn about a virus, its level of danger, the way it accesses your computer, and what you can do to protect yourself. There is a library of security news, with in-depth coverage of newsworthy stories about security breaches and solutions. The articles library has easy-to-understand information about how the Internet works, how virus and Trojan horse attacks happen, what Java and ActiveX files are, how firewalls work, and other topics that you need to know to ensure safe computing. PC Flank has links to the most popular anti-virus, anti-Trojan, and firewall software. You can even submit suspicious files that you've found on your computer, and the experts at PC Flank will analyze them for free, and tell you if you've been infected.

JENSEN POWERS NEW PRO REVERB AMPLIFIER

Fender Musical Instruments of Scottsdale, AZ, has recently announced the release of a new 50 watt, all tube, Pro Reverb combo amp, featuring Jensen C12N Vintage Speakers. The Jensen C12N speaker was carefully selected to match the circuitry used in the Pro Reverb, which can provide bell-like clean tones from its vintage Fender Blackface-style normal channel, and thick, creamy shades from the super hot drive channel.

The Pro Reverb amplifier represents a "first" for Fender in that they have never released an amplifier with both Tremolo and high-gain channel switching. The Pro Reverb amplifier touts true tube reverb and tremolo, and a full-featured effects loop. Fender amplifiers and Jensen speakers have a long history of combining to provide that unmistakable Fender sound.

Jensen Vintage Speakers are made to replicate the tone and specifications of the original Jensen speakers. They are distributed in the US by CE Distribution, (Tempe, AZ) a subsidiary of Campanella Enterprises. CE Distribution is

NEWS BYTES Continued on Page 81

OSCILLOSCOPES & ACCESSORIES

OSCILLOSCOPES

TEK 2430-opt 03,11 100 MS/s Dual Channel Oscilloscope, TV trigger, GPIB $1,200.00

TEK 7104 1 GHz 2-Channel Oscilloscope, w/7A29,7A29-04,7B10,7B15 ..... $2,000.00

PROBES

TEK 1101 Accessory Power Supply, for FET probes $175.00

TEK A6302B Voltage Isolator, DC-20 MHz, 20 mV-500 V/div. $500.00

TEK P6201 900 MHz 1X/10X/100X FET Probe $400.00

TEK P6202 500 MHz 10X FET Probe $150.00

TEK P6701-opt.02 O/E Converter, 450-1050 nm,0-1 mW: DC-700 MHz, ST conn. $175.00

WAVEFORM GENERATORS

FUNCTION

HP 3310A 5 MHz Function Generator $250.00

HP 3312A 13 MHz Function Generator $500.00

HP 3326A-001,21 MHz Synthesizer Function Generator, OCXO reference $1,100.00

HP 3325A-002,21 MHz Synthesizer,Function Generator, HV output option $1,200.00

TEK AWG5102 Arb.Waveform Gen.,20 MS/s,12 bits, 50ppm synthesis <1 MHz $650.00

TEK AWG5105-opt.02 Arb trary Waveform Generator, dual channel option $800.00

TEK DG501 D gital Delay & Burst Gen., for function & pulse gen s. $200.00

TEK FG5010 Programmable 20 MHz Function Generator, TM5000 series $800.00

TEK FG501A 2 MHz Function Generator, TM500 series $275.00

TEK FG502 11 MHz Function Generator, TM500 series $275.00

TEK FG503 3 MHz Function Generator, TM500 series $250.00

TEK RG501 Ramp Generator, TM500 series $175.00

WAVETEK 288 20 MHz Synthesized Function Generator, GPIB $650.00

PULSE

BERKELEY NUCLEONICS 7055B D g tal Delay Generator, 0-100 mS, 1 nS res.,5 Hz-5 MHz $400.00

HP 214B-001 10 MHz Pulse Generator, up to 50 V/ 50 Ohms $1,400.00

HP 8007B 100 MHz Pulse Generator $450.00

HP 8012B 50 MHz Pulse Generator, variable transition time $600.00

HP 8013A 50 MHz Dual Output Pulse Generator $500.00

HP 8013B 50 MHz Dual Output Pulse Generator $600.00

TEK PG502 250 MHz Pulse Generator, 1ns-1nS, TM500 series $500.00

TEK PG508 50 MHz Pulse Generator, TM500 series $350.00

VOLTAGE & CURRENT

VOLTMETERS

FLUKE 845AR High Impedance Voltmeter / Null Detector $400.00

HP 3456A 6-1/2 Digit Voltmeter, HPIB $450.00

HP 3457A 7-1/2 digit Voltmeter, HPIB $1,000.00

HP 3478A 5-1/2 digit Multimeter, HPIB $450.00

KEITHLEY 181 6-1/2 digit Nanovoltmeter, 10 nV sensitivity, GPIB $675.00

SOLARTRON 7081 8-1/2 digit Voltmeter $3,000.00

TEK DM5010 4-1/2 digit Multimeter, TM5000 series plug-in $300.00

TEK DM501A 4-1/2 digit Multimeter, TM500 series plug-in $225.00

CALIBRATION

FLUKE 510A AC Reference Standard, 10 VRMS, 0-10 mA $450.00

FLUKE 5220A Transconductance Amplifier, DC-5 kHz, 0-20 A $1,400.00

VOLTAGE SOURCES

HP 6114A Precision Power Supply, 0-20 V 0-2 A / 20-40 V 1 A $850.00

HP 6115A Precision Power Supply, 0-50V 0-0.8A / 0-100V 0-0.4A $750.00

KEITHLEY 228 Programmable Voltage,Current Source $1,900.00

CURRENT METERS & SOURCES

HP 6177C DC Current Source, to 50 V, 500 mA $500.00

HP 6181C DC Current Source, to 100 V, 250 mA $500.00

HP 6186C DC Current Source, to 300 V, 100 mA $750.00

KEITHLEY 225 Current Source, 0.1 uA-100 mA, 10-100 V compliance $450.00

TEK CT-5 High Current Transformer for P6021/A6302, to 1000A $375.00

TEK P6022 AC Current Probe w/termination, 935 Hz-120 MHz, 6 A pp $250.00

IMPEDANCE & COMPONENT TEST

L,C,R

VALHALLA 2500 AC-DC Current Calibrator, 2 uA- 2 A, DC-10 kHz $675.00

BOONTON 62AD 1 MHz Inductance Meter, 2-2000 uH $550.00

BOONTON 72BD 1 MHz Capacitance Meter, 2-2000 pf s. $800.00

BOONTON 72C 1 MHz Capacitance Meter, 1-3000 pF full scale $800.00

GR 1658 RLC Digibridge, 120 Hz/ 1 kHz $1,000.00

HP 4262A 3-1/2 digit LCR Meter, 120 Hz/ 1 kHz/ 10 kHz $950.00

HP 4274A 5-1/2 digit LCR Meter, 100 Hz-100 kHz, HPIB $3,250.00

STANDARD

E.S.I. SR-1 Standard Resistor, various values $125.00

E.S.I. SR1010 Resistance Transfer Standards, 1 Ohm-100 K/step $550.00

GENERAL RADIO 1409-series Standard Capacitors $150.00

GR 1406-series Standard Air Capacitors, GR900 connector, 0.1% acc. $275.00

GR 1433-U 4-Decade Resistor, 0-111.10 Ohms, 0.01 Ohm resolution $100.00

GR 1433-J 4-Decade Resistor, 0-11,110 Ohms, 1 Ohm resolution $150.00

GR 1433-K 4-Decade Resistor, 0-1,110 Ohms, 0.1 Ohm resolution $150.00

GR 1433-P 5-Decade Resistor, 0-1.1111 Megohm, 10 Ohm resolution $500.00

HP 4440B Decade Capacitor, 40 pF-1.2 uF $750.00

HI & LO RESISTANCE

HP 4329A High Resistance Meter $1,000.00

T,D,R

TEK 1503B-03,04 T.D.R., 0-50,000 ft., chart recorder & battery power $3,000.00

POWER SUPPLIES

SINGLE OUTPUT

HP 6002A-001 0-50 V / 0-10 A / 200 Watts maximum Power Supply, HPIB $650.00

HP 6011A 0-20 V/ 0-120 A/ 1000 Watts max. CV/CC Power Supply $1,800.00

HP 6003A Power Supply, 0-20 V / 0-30 A / 200 Watts max., HPIB $1,200.00

HP 6038A Power Supply, 0-60 V / 0-10 A / 200 Watts max., HPIB $1,200.00

HP 6203B 0-7.5 V 0-3 A CV/CC Power Supply $175.00

HP 6207B 0-160 V 0-200 mA CV/CC Power Supply $200.00

HP 6263B 0-20 V 0-10 A CV/CC Power Supply $375.00

HP 6266B 0-40 V 0-5 A CV/CC Power Supply $375.00

HP 6267B 0-40 V 0-10 A CV/CC Power Supply $550.00

HP 6271B 0-60 V 0-3 A CV/CC Power Supply $375.00

HP 6274B 0-60 V 0-15 A CV/CC Power Supply $650.00

HP 6299A 0-100 V 0-750 mA CV/CC Power Supply $200.00

HP 6384A 4 0-5.5 V at 8 A CV/CL Power Supply $125.00

HP 6443B 0-120 V 0-2.5 A CV/CC Power Supply $450.00

HP 6515A 0-1500 V 0-5 mA CV/CL Power Supply $275.00

HP 6525A 0-4000 V 0-50 mA CV/CC Power Supply $650.00

HP 6552A 0-20 V 0-25 A CV/CC Power Supply $1,000.00

HP 6643A 0-35 V 0-6 A CV/CC Power Supply, HPIB $1,200.00

HP 6652A 0-20 V 0-25 A 500 Watt Programmable Power Supply, HPIB $1,875.00

KEPCO ATE 36-6M 0-36 V 0-6 A CV/CC Power Supply $375.00

LAMBDA LK-352-FM 0-60 V 0-15 A CV/CC Power Supply $600.00

SORENSON SRL 20-12 0-20 V 0-12 A CV/CC Power Supply $350.00

SORENSON SRL 60-8 0-60 V 0-8 A CV/CC Power Supply $500.00

HP 6205C Dual Power Supply, 0-40 V 300 mA & 0-20 V 600 mA, CV/CL $300.00

MULTIPLE OUTPUT

HP 6228B Dual 0-50 V 0-1 A CV/CC Power Supply $375.00

HP 6236B Triple Output Power Supply $375.00

HP 6253A Dual 0-20 V 0-3 A CV/CC Power Supply $375.00

HP 6255A Dual 0-40 V 0-1.5 A CV/CC Power Supply $375.00

TEK PS503A Dual Power Supply, TM500 series $200.00

MISCELLANEOUS

ACME PS2L-500 Programmable Load, 0-75 V / 0-75 A / 500 Watts max. $350.00

BEHLMAN 25-C-D OSCD-1 AC Power Source, 250 VA, 0-130 VAC, 45-2000 Hz $850.00

HP 6050B HPIB Isolated AC/Power Supply Programmer $175.00

HP 6060A 300 Watt Programmable Load, 0-60 A / 3-60 V, HPIB $950.00

HP 6826A Bipolar Power Supply/ Amplifier, to 50 V 1 A $900.00

HP 6827A Bipolar Power Supply/ Amplifier, to 100 V, 0.5 A $900.00

KEPCO BOP 50-2M Bipolar Op Amp/Power Supply, to 50 V 2 A $400.00

TRANSISTOR DEVICES DAL-50-15-100 Programmable Load, 0-50 V, 0-15 A, 100 Watts max. $200.00

TIME & FREQUENCY

UNIVERSAL COUNTERS

HP 5314A 100 MHz/ 100 nS Universal Counter $175.00

HP 5315A 100 MHz/100 nS Universal Counter $350.00

HP 5315A-003 100 MHz/100 nS Univ. Counter, 1 GHz C-channel option $450.00

HP 5315B 100 MHz/ 100 nS Universal Counter $375.00

HP 5316A 100 MHz/100 nS Universal Counter, HPIB $450.00

PHILIPS PM6672/411 120 MHz/100 nS Universal Counter, C-channel 70-1000 MHz $375.00

TEK DC5004 Programmable 100 MHz/100nS Counter/Timer, TM5000 series $200.00

TEK DC5009 Programmable 135 MHz Univ. Counter/Timer, TM5000 series $350.00

TEK DC503A 125 MHz/100 nS Universal Counter, TM500 series $275.00

TEK DC509 135 MHz/ 10 nS Universal Counter, TM500 series $275.00

FREQUENCY COUNTERS

EIP 548A-06 26.5 GHz Frequency Counter, w/mixers 26-60 GHz $3,950.00

EIP 578-opt-s 02,05 26.5 GHz Source Locking Counter; GPIB & power meter opt. $2,750.00

FLUKE 7220A-010,131,351 1.3 GHz Counter; battery power, OCXO, and res. mult. $500.00

HP 5342A 18 GHz Frequency Counter $900.00

HP 5343A-001 26.5 GHz Frequency Counter, OCXO reference $2,650.00

HP 5345A/5355A/5356B 26.5 GHz CW/Pulse Frequency Counter $3,500.00

HP 5352B-001,005 46 GHz Frequency Counter, ovenized xtal reference $8,500.00

HP 5384A Microwave Mixer / Detector, for modulation domain an. $2,000.00

HP 5384A 225 MHz Frequency Counter, HPIB $450.00

STANDARDS

HP 105B Quartz Oscillator, 0.1/ 1.0/ 5.0 MHz, battery power $1,100.00

AUDIO & BASEBAND

SPECTRUM ANALYSIS

HP 3586C Selective Level Meter, 50 Hz-32.5 MHz, 50 & 75 ohms $1,200.00

DISTORTION ANALYZERS

HP 8903A Audio Analyzer, 20 Hz-100 kHz $1,200.00

HP 8903B-001,010,053 Audio Analyzer, 20 Hz-100 kHz, HPIB $1,850.00

HP 8903E Audio Analyzer, 20 Hz-100 kHz, HPIB $1,650.00

RMS VOLTMETERS

FLUKE 8922A True RMS Voltmeter, 180 uV-700 V, 2 Hz-11 MHz $450.00

OSCILLATORS

TEK SG502 Sine/Square Osc., 5 Hz-500 kHz, 70 dB step atten., TM500 ..... $200.00

TEK SG505-opt 02 Oscillator, 10 Hz-100 kHz, IM test & 50/150/600 Ohms $950.00

WAVETEK 98 1 MHz Synthesized Power Oscillator, GPIB $950.00

MISCELLANEOUS

HP 3575A Phase-Gain Meter, 1 Hz-13 MHz, single display $600.00

HP 3575A-001 Phase-Gain Meter, 1 Hz-13 MHz, dual display $850.00

HP 467A Power Amplifier $375.00

KROHN-HITE 3200 High Pass / Low Pass Filter, 20 Hz-2 MHz, 24 dB/octave $275.00

KROHN-HITE 3202 Dual HP/LP/BP/BR Filter, 20 Hz-2 MHz, 24 dB/octave $450.00

ROCKLAND 852 Dual Highpass/Lowpass Filter, 0.1 Hz-111 kHz $650.00

TEK AM502 1 MHz Differential Amplifier, TM500 series $450.00

RF & MICROWAVE

SPECTRUM ANALYZERS

HP 11517A/19A/20A Mixer Set, 18-40.0 GHz, for HP 8555A/8559A $475.00

HP 11970A WR28 Harmonic Mixer, 26.5-40 GHz $1,100.00

HP 11970K WR42 Harmonic Mixer, 18.0-26.5 GHz $1,100.00

HP 11970Q WR22 Harmonic Mixer, 33-50 GHz $1,400.00

HP 11970U WR19 Harmonic Mixer, 40-60 GHz $1,600.00

HP 11971A WR28 Harmonic Mixer, for HP 8569B $800.00

HP 11971K WR42 Harmonic Mixer, for HP 8569B $800.00

HP 8559A/853A-001 Spectrum An., 0.01-21 GHz, 1 kHz res.,w/rackmount frame $3,500.00

HP 85640A Tracking Generator, 300 kHz-2.9 GHz, for HP 8560 series $5,000.00

HP 8565A-100 Spectrum Analyzer, 10 MHz-22 GHz, 100 Hz min. res. bw $3,000.00

HP 8568B Spectrum Analyzer, 100 Hz-1.5 GHz, 10 Hz min. res. $8,500.00

HP 8569B Spectrum Analyzer, 10 MHz-22 GHz, 100 Hz min.res.bw $5,500.00

TEK WM782V WR15 Harmonic Mixer, 50-75 GHz $1,500.00

NETWORK ANALYZERS

HP 11650A Network Analyzer Accessory Kit, APC7 ..... $600.00

HP 11665B Modulator, 0.15-18 GHz, for HP 8755/G/7 ..... $250.00

HP 3577A Network Analyzer, 5 Hz-200 MHz $7,500.00

HP 8502B 75 Ohm Transmission/ Reflection Test Unit, 0.5-1300 MHz $675.00

HP 85044B 75 Ohm Transmission/Reflection Test Unit, 300 kHz-2 GHz $1,600.00

HP 85054A Type N Calibration Kit, for HP 8510 series $1,800.00

Circle #47 on the Reader Service Card.

HP 8717A Transistor Bias Supply $500.00
HP 8756A Scalar Network Analyzer, HPIB $1,375.00
HP R8502A WR28 Detector, 26.5-40 GHz, for HP 8757 series $1,200.00

SIGNAL GENERATORS

FLUKE 6060A Synthesized Signal Gen., 0.1-1050 MHz, 10 Hz res. $1,500.00
FLUKE 6060B/AK Synthesized Signal Gen., 0.1-1050 MHz, 10 Hz res. $1,900.00
GIGATRONICS 1018 Synth Signal/Sweep Gen., 0.05-18 GHz, 1 kHz res, +8 dBm $5,000.00
GIGATRONICS 600-8-12 Synthesized Source, 6-12 GHz, 1 MHz res., GPIB $1,500.00
GIGATRONICS 6000-8-16 Synthesized CW Gen., 8-16 GHz, 1 MHz res., +10 dBm $2,250.00
GIGATRONICS 875/50 Levelled Multiplier, x4, 50.0-75.0 GHz output, -3 dBm $2,500.00
GIGATRONICS 8-9902-8 Synthesized Signal/Sweep Gen., 2-8 GHz, 1 MHz res., GPIB $2,000.00
HP 11707A Test Plug-in for HP 8660 series $500.00
HP 11720A Pulse Modulator, 2-18 GHz, 80 dB on/off ratio $450.00
HP 8656B-001 Signal Generator, 0.1-990 MHz, 10 Hz res., HPIB, OCXO $2,750.00
HP 8660C/8660A/B/8633B Synthesized Signal Generator, 1-2600 MHz, AM, FM $3,250.00
HP 8660D/8663A 002 Synthesizer, 1-2600 MHz, phase modulation (8663A) $6,000.00
HP 8672A Synthesized Signal Generator, 2-18 GHz, +3 dBm output $4,500.00
HP 8673H-212 Synthesized Signal Generator, 2.0-12.4 GHz, 1 kHz res. $8,750.00
HP 8673M Synthesized Signal Generator, 2-18 GHz, +8 dBm Po $9,500.00
HP 8683B Signal Generator, 2.3-6.5 GHz, AM/ WBFM/ Pulse $2,250.00
HP 8683D Signal Generator, 2.3-13.0 GHz, AM/ WBFM/ Pulse $3,750.00
HP 8684B Signal Generator, 5.4-12.5 GHz, AM/ WBFM/ Pulse $3,000.00
HP 8684D-001 Signal Generator, 5.4-18.0 GHz, AM/WBFM/Pulse, +10 dBm $3,750.00
WAVETEK 952 Signal Generator, 1-4 GHz, +10 dBm, AM, FM $750.00
WAVETEK 957 Signal Generator, 12-18 GHz, +7 dBm, AM, FM $750.00

SWEEP GENERATORS

HP 8350B/83522A Sweep Oscillator, 10-2400 MHz, +13 dBm levelled $3,750.00
HP 8350B/83525A Sweep Oscillator, 10 MHz-8.4 GHz, +13 dBm levelled $5,000.00
HP 8350B/83540A-002,004 Sweep Oscillator, 2.0-8.4 GHz, 70 dB step attenuator $3,250.00
HP 8350B/83545A-002 Sweep Oscillator, 5.9-12.4 GHz, 70 dB step attenuator $3,750.00
HP 8350B/83570A Sweep Oscillator, 18.0-26.5 GHz, +10 dBm levelled $7,500.00
HP 8350B/83570A-H22 Sweep Oscillator, 17.24 GHz, +10 dBm levelled $5,000.00
HP 8601A Generator/Sweeper, 0.1-110 MHz, +20 dBm levelled $400.00
HP 8620C Sweep Oscillator Frame $550.00
HP 86222B-002 RF Plug-In, 10-2400 MHz, +13 dBm lvld., 70 dB step att. $1,250.00
HP 86222B-E66/8620C Sweep Oscillator, 0.01-2 GHz & 2-4 GHz, +10 dBm, w/frame $1,200.00
HP 86241A-001 RF Plug-In, 3.2-6.5 GHz, +8 dBm levelled $300.00
HP 86251A RF Plug-in, 7.5-18.6 GHz, +10 dBm levelled $500.00
HP 86260A RF Plug-in, 12-18 GHz, +10 dBm unlevelled $400.00
HP 86290B-H04 RF Plug-In, 10.0-15.0 GHz, +10 dBm unlevelled $400.00
HP 86290A RF Plug-in, 2.0-18.0 GHz, +7 dBm levelled $1,200.00
HP 86290B RF Plug-in, 2.0-18.6 GHz, +10 dBm levelled $1,650.00
HP 86290C RF Plug-in, 2.0-18.6 GHz, +13 dBm levelled $1,850.00
WAVETEK 2001 Sweep Generator, 1-1400 MHz, +10 dBm, 70 dB step attenuator $900.00
WAVETEK 2002B Sweep Generator, 1-2500 MHz, +13 dBm, 70 dB att., GPIB $1,750.00
WILTRON 6647M Programmable Sweep Generator, 10 MHz-20 GHz, +10 dBm $4,500.00
WILTRON 6717B-20 Freq. Synth./ Sweeper, 10 MHz-8.4 GHz, +13 dBm, AM, FM $6,500.00

POWER METERS

BOONTON 42B/41-4E Analog Power Meter, with 1 MHz-18 GHz sensor $450.00
HP 435B/8481A Power Meter, -30 to +20 dBm, 10 MHz-18 GHz $900.00
HP 436A-022/8481A Power Meter, -30 to +20 dBm, 10 MHz-18 GHz, HPIB $1,200.00
HP 436A-022/8482A Power Meter, -30 to +20 dBm, 100 kHz-4.2 GHz, HPIB $1,200.00
HP 436A-022/8484A Power Meter, -70 to -20 dBm, 10 MHz-18 GHz, HPIB $1,200.00
HP 436A-022/8485A Power Meter, -30 to +20 dBm, 50 MHz-26.5 GHz, HPIB $1,500.00
HP 8477A Power Meter Calibrator, for HP 432 series $400.00
HP 8486A Power Sensor, 33.0-50.0 GHz, WR22, for 435/8478 ..... $1,500.00
HP R8486A WR28 Power Sensor, 26.5-40 GHz, for HP 435/8/7/8 ..... $1,500.00

RF MILLIVOLTMETERS

BOONTON 92C RF Millivoltmeter, 3 mV-3 V f.s., 10 kHz-1.2 GHz $500.00
RACAL-DANA 9303 RF Millivoltmeter, 10 kHz-2 GHz, -70 to +20 dBm $750.00

APLIFIERS, MISCELLANEOUS

AMPLIFIER RESEARCH 4W1000 Amplifier, 40 dB gain, 4 Watts, 1-1000 MHz $950.00
BOONTON 82AD Modulation Meter, AM / FM, 10-1200 MHz $650.00
C.P.I. VZC6961K1 TWT Amplifier, 35 dB gain, 4-8 GHz, 20 Watts $3,500.00
ENI 5100L Amplifier, 50 dB gain, 1.5-400 MHz, 100 Watts $7,500.00
ENI 525LA Amplifier, 50 dB gain, 1-500 MHz, 25 Watts $3,250.00
HP 11713A Switch Attenuator Driver, HPIB $900.00
HP 11729B-003 Carrier Noise Test Set, 5 MHz-3.2 GHz $2,250.00
HP 415E SWR Meter $200.00
HP 8406A Comb Generator, 1/ 10/ 100 MHz Increments, to 5 GHz $500.00
HP 8447E Amplifier, 22 dB, 0.1-1300 MHz, +13 dBm output $750.00
HP 8447F-H64 Dual Amp., 9 kHz-50 MHz 28 dB & 0.1-1300 MHz 25 dB $900.00
HP 8901A Modulation Analyzer, 150 kHz-1300 MHz $1,500.00
HP 8901B-1,2,3 Modulation An., 0.15-1300 MHz, rear input, OCXO, ext LO $2,000.00
HP 8970A Noise Figure Meter $3,750.00
HUGHES 8010H13F000 TWT Amplifier, >30 dB gain, 3-8 GHz, 10 Watts $2,500.00
RACAL 9009 Modulation Meter, 30-1500 MHz, AM & FM (1.5-100 MHz pk) $350.00
RF POWER LABS ML50 Amplifier, 2-30 MHz, 47 dB gain, 50 Watts, metered, 28V $225.00
ROHDE & SCHWARTZ ESH2 Test Receiver, 9 kHz-30 MHz $3,750.00
VARIAN VZM6791K3 TWT Amplifier, 38 dB gain, 8-18 GHz, 20 Watts $3,500.00

COAXIAL & WAVEGUIDE

AEROWAVE 28-3000/10 WR28 Directional Coupler, 10 dB, 26.5-40 GHz $300.00
AMERICAN NUCLEONICS AM-432 Cavity Backed Spiral Antenna, LHC, 2-18 GHz,TNC(f) *NEW* $95.00
AVANTEK AMT-400X2 WR28 Activo Doubler, +10 dBm in/ +10 dBm out 26-40 GHz $450.00
BIRD 8201 500 Watt Oil Dielectric Load, DC-2.5 GHz, N(f) $350.00
FXR/M CROLAB SL-03N Slub Stretcher, 0.3-6.0 GHz, 100 Watts max., N(m/f) $75.00
GR 874-LTL Constant Impedance Trombone Line, 0-44 cm, DC-2 GHz $400.00
HP 11590A-001 Bias Network, 1.0-18.0 GHz, APC7 ..... $450.00
HP 11691D-001 Directional Coupler, 22 dB, 2-18 GHz, N(f)-all ports $450.00
HP 11692D Dual Directional Coupler, 22 dB, 2-18 GHz $800.00
HP 33327L-006 Programmable Step Attenuator, 0-70 dB, DC-40 GHz, 2.9mm $1,000.00
HP 778D-011 Dual Dir. Coupler, 20 dB, 100-2000 MHz, APC7 test port $450.00
HP 8431A 2-4 GHz Band Pass Filter, N(m/f) $150.00
HP 87300C-020 Directional Coupler, 20 dB, 1.0-26.5 GHz, 3.5mm $475.00
HP K422A WR42 Flat Broadband Detector, 18.0-26.5 GHz $350.00
HP K532A WR42 Frequency Meter, 18.0-26.5 GHz $450.00
HP K752A WR42 Directional Coupler, 3 dB, 18.0-26.5 GHz $450.00
HP K752C WR42 Directional Coupler, 10 dB, 18.0-26.5 GHz $450.00
HP K752D WR42 Directional Coupler, 20 dB, 18.0-26.5 GHz $450.00
HP K870A WR42 Slide Screw Tuner, 18.0-26.5 GHz $275.00
HP K914B WR42 Moving Load, 18.0-26.5 GHz $300.00
HP Q752D WR22 Directional Coupler, 20 dB, 33-50 GHz $650.00
HP R422A WR28 Crystal Detector, 26.5-40 GHz $400.00
HP R752D WR28 Directional Coupler, 20 dB, 26.5-40 GHz $450.00
HP R914B WR28 Moving Load, 26.5-40 GHz $250.00
HP V365A WR15 Isolator, 25 dB, 50-75 GHz $750.00
HP V752D WR15 Directional Coupler, 20 dB, 50-75 GHz $650.00
HP X870A WR90 Slide Screw Tuner $150.00
HUGHES 45322H-1110/1120 WR22 Directional Couplers, 10 or 20 dB, 33-50 GHz $350.00
HUGHES 45712H-1000 WR22 Frequency Meter, 33-50 GHz $750.00
HUGHES 45714H-1000 WR15 Frequency Meter, 50-75 GHz $900.00
HUGHES 45721H-2000 WR28 Direct Reading Attenuator, 0-50 dB, 26.5-40 GHz $1,000.00
HUGHES 45722H-1000 WR22 Direct Reading Attenuator, 0-50 dB, 33-50 GHz $1,000.00
HUGHES 45724H-1000 WR15 Direct Reading Attenuator, 0-50 dB, 50-75 GHz $1,000.00
HUGHES 45732H-1200 WR22 Level Set Attenuator, 0-25 dB, 33-50 GHz $250.00
HUGHES 45752H-1000 WR22 Direct Reading Phase Shifter, 0-360 deg.,33-50 GHz $1,400.00
HUGHES 45772H-1100 WR22 Thermistor Mount, -20 to +10 dBm, 33-50 GHz $400.00
HUGHES 45773H-1100 WR19 Thermistor Mount, -20 to +10 dBm, 40-60 GHz $650.00
HUGHES 45774H-1100 WR15 Thermistor Mount, -20 to +10 dBm, 50-75 GHz $750.00
HUGHES 47316H-1111 WR10 Tuneable Detector, 75-110 GHz, positive polarity $600.00
HUGHES 47741H-2310 WR28 Phase Locked Gunn Osc., 32.000 GHz, +18 dBm $2,000.00
HUGHES 47742H-1210 WR22 Phase Locked Gunn Osc., 42.000 GHz, +18 dBm $2,750.00
KRYTAR 201020010 Directional Detector, 1-20 GHz, SMA(f/f)/SMC $200.00
KRYTAR 2616S Directional Detector, 1.7-26.5 GHz, K(f/m)/SMC $200.00
M/A-COM 3-19-3000/10 WR19 Directional Coupler, 10 dB, 40-60 GHz $450.00
MICA C-121S06 Circulator, 17.5-24.5 GHz, SMA(f/m/m) $75.00
NARDA 3000-series Directional Couplers $150.00
NARDA 3020A Bi-Directional Coupler, 50-1000 MHz, N $500.00
NARDA 3024 Bi-Directional Coupler, 20 dB, 4-8 GHz $375.00
NARDA 3090 SERIES Precision High Directivity Couplers $225.00
NARDA 3688NM Coaxial High Power Load, 500 Watts, 2.0-18 GHz, N(m) $500.00
NARDA 3752 Coaxial Phase Shifter, 0-180 deg./GHz, 1-5 GHz $900.00
NARDA 3753B Coaxial Phase Shifter, 0-55 deg./GHz, 3.5-12.4 GHz $950.00
NARDA 4000-SERIES SMA Miniature Directional Couplers $75.00
NARDA 4247-20 Directional Coupler, 20 dB, 8.0-26.5 GHz, 3.5mm(f) $200.00
NARDA 5070-series Precision Reflectometer Couplers $300.00
NARDA 562 DC Block, 10 MHz-12.4 GHz, 100 V max., N(m/f) $65.00
NARDA 765-10 10 dB Attenuator, 50 Watts, DC-5 GHz, N(m/f) $165.00
NARDA 791FM Variable Attenuator, 0-37 dB, 2.0-12.4 GHz $600.00
NARDA 792FF Variable Attenuator, 0-20 dB, 2.0-12.4 GHz $375.00
NARDA 793FM Direct Reading Variable Attenuator, 0-20 dB, 4-8 GHz $225.00
NARDA 794FM Direct Reading Variable Attenuator, 0-40 dB, 4-8 GHz $375.00
OMNI-SPECTRA 2085-6010-00 Crystal Detector, 1-18 GHz, negative polarity, SMA(m/f) $50.00
PAMTECH KYG1014 WR42 Junction Circulator, 18.0-26.5 GHz $250.00
SONOMA SCIENTIFIC 21A3 WR42 Circulator, 20 dB, 20.6-24.8 GHz $75.00
TEKTRONIX 2701 Step Attenuator, 0-79 dB, DC-1 GHz, AC or DC coupled $175.00
TRG 8510 WR22 Direct Reading Attenuator, 0-50 dB, 33-50 GHz $900.00
TRG V551 WR15 Frequency Meter, 50-75 GHz $600.00
TRG W510 WR10 Direct Reading Attenuator, 0-50 dB, 75-110 GHz $1,000.00
TRG W551 WR10 Frequency Meter, 75-110 GHz $750.00
WAVELINE 100080 WR28 Terminated Crossguide Coupler, 30 dB $200.00
WEINSCHEL 150-110 Programmable Step Attenuator, 0-110 dB, DC-18 GHz, SMA $450.00
WEINSCHEL DS109 Double Stub Tuner, 1-13 GHz, N(m/f) $150.00
WEINSCHEL DS109LL Double Stub Tuner, 0.2-2.0 GHz, N(m/f) $150.00

COMMUNICATIONS

HP 37204A-003 HPIB Extender, fibre-optic connection *NEW OLD STOCK* $350.00
HP 59401A HPIB Bus Analyzer $375.00
TAMPA MICROWAVE LAB BUC1W-02-W-CST Ku band Upconverter, 1 Watt 14.0-14.5 GHz WR75 *NEW* $225.00
TEK 1411R PAL Gen.,w/SPG12 sync,TSG11 color bars; TSG13 linearity $750.00
TEK 1411R PAL Test Gen., w/SPG12,TSG11,TSG13,TSG15, TSG16 ..... $1,000.00
TEK 1411R PAL Test Gen., w/SPG12,TSG11,TSG12,TSG13, TSG15,TSG16 ..... $1,100.00
TEK 1411R-opt.04 PAL Test Gen.,w/ SPG12,TSG11,TSP11,TSG13,TSG15,TSG16 ..... $1,400.00
TEK 147A NTSC Test Signal Generator, with noise test signal $800.00
TEK 148 PAL Insertion Test Signal Generator $700.00
TEK 520A NTSC Vectorscope $750.00
TEK 521A PAL Vectorscope $750.00

MISCELLANEOUS

EG&G / P.A.R. 5302 / 5316 Lock-in Amplifier, 100 mHz-1 MHz, GPIB /RS232C $2,250.00
FLUKE 2180A RTD Digital Thermometer $500.00
HP 59307A HPIB VHF Switch $200.00
P.A.R. 5206-95,98 Two-Phase Lock-in Amp., 2 Hz-100 kHz, GPIB $1,500.00
TEK TM5003 5000-series 3-slot Programmable Power Module $450.00
TEK TM5006 5000-series 6-slot Programmable Power Module $500.00
TEK TM504 500-series 4-slot Power Module $175.00
TEK TM506 500-series 6-slot Power Module $250.00
TEK TM515 500-series 5-slot Traveller Power Module $250.00

HAMS (THE RADIO TYPE) IN HOG HEAVEN


Ham radio email is free!

by Gordon West

It has been over a year now since the amateur radio service was restructured by the Federal Communications Commission (FCC). In the 15 months after restructuring, ham operators are in almost unanimous agreement about the hobby getting back on track with yearly positive growth figures.

"All license classes show a dramatic 30 percent growth immediately after restructuring," comments Julian Frost N3JF, an amateur radio Morse Code instructor.

"When code requirements were reduced from 20 and 13 wpm down to 5 wpm for all classes of license, my 5 wpm code classes were an instant sellout," adds Frost. "Amateur radio is now a very healthy hobby," adds Frost, reminding us that prior to restructuring, most of the amateur radio classes were steadily dropping in numbers.

This ham set does double-duty to display closed circuit TV images, too.

THE RESTRUCTURING PROCESS

The FCC is required to review all of their regulations applicable to providers of telecommunications service, and must determine whether any rule is no longer in the public interest as a result of meaningful economic competition between providers of telecommunication services, and whether such regulations should be deleted or modified.

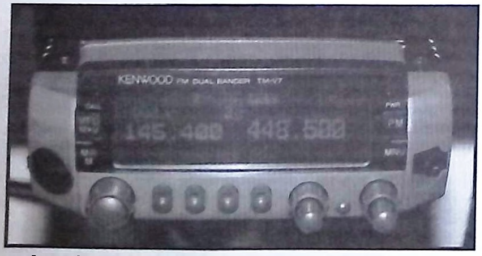
In 1998, the amateur radio service came under FCC study in an effort to eliminate unnecessary and duplicative rules, as well as to streamline the licensing process. And during their two-year review, the FCC received thousands of comments from hams and non-hams on how the service might be restructured to keep it viable, exciting, and in step with today's technology of satellites, computers, email, and video imaging over the Internet. Many commentors said that amateur radio can do all of this, and without wires!

In December 1999, after studying all of the thousands of comments that came in from amateur radio operators and amateur radio organizations throughout the country, the FCC substantially simplified and streamlined the amateur service:

A. Reducing the number of license classes from six to three — Technician, General, and amateur Extra class. Holders of Novice and Advanced class, and Technician-plus class licenses would keep their present privileges, their present call sign, and their present license class for as long as they continue to renew their license.

B. Three written exams — 35 questions for Technician, 35 questions for General, and 50 questions for amateur Extra. No more testing for Advanced class or Novice class.

C. The emphasis on Morse Code would be reduced to the minimum 5 wpm examination rate that would satisfy the International Radio Regulation (IRR) which calls for manual telegraphy proficiency at 5 wpm when operating on the high-frequency ham bands.



A typical VHF/UHF dual band mobile ham radio.

"Since those revisions became effective in April 2000, over 30,000 amateur operators have qualified for amateur service licenses that will now authorize greater operating privileges," states the Commission. An example of this would be middle-aged Technician class operators who tested for their Technician license prior to March of 1987. Now that General and Extra class code speeds are the same 5 wpm, these older "grandfathered" Technician class operators having originally passed all the required written elements for General may now apply for General class operating privileges. No further code or theory test required for grandfathered Techs prior to March of 1987!

The new restructuring rules would now give General class and Advanced class operators an easy path to Extra class — take only one more written examination, and no 20 wpm code test required. Thousands of General class and Advanced class hams immediately hit the books, and upgraded to Extra class within a year.

To non-hams, the amateur radio service would now be easier than ever to enter because a single Element 2 Technician written exam would get them on the air with voice, code, data, and video privileges on all bands from 50 MHz

Table 1: Current Amateur License Classes and Exam Requirements (Effective April 15, 2000)

License Class	Exam Element	Type of Examination
Technician Class	2	35-question, multiple-choice written examination. Minimum passing score is 26 questions answered correctly (74%).
General Class	3	35-question, multiple-choice written examination. Minimum passing score is 26 questions answered correctly (74%). Also requires assing Element 1 Morse code test.
Extra Class	4	50-question, multiple-choice written examination. Minimum passing score is 37 questions answered correctly (74%).
Morse Code	1	Demonstrate ability to receive Morse code at a 5-word-per-minute rate. (See Chapter 4 for more information and an example test.)

Table 2: Previous Amateur License Classes and Exam Requirements (Prior to April 15, 2000)

Grandfathered License Class	Exam/Test Elements	Type of Examination
Novice	Element 2 & Element 1A	35-question written examination, 5-wpm code test
Technician	Element 2 & 3A	65-question written examination in two parts (35 Element 2 plus 30 Element 3A questions) (No Morse code requirement)
Technician-Plus	Element 2, Element 3A, and Element 1A	35-question written examination, and 30-question written examination, and 5-wpm code test
General	Element 3B & Element 1B	30-question written examination 13-wpm code test
Advanced	Element 4A	50-question written examination (No additional Morse code requirement)
Extra	Element 4B & Element 1C	40-question written examination 20-wpm code test

and up. Since the Novice test was eliminated, the Technician entry-level license was now twice as easy or half as long to pass!

The new rules effective April of last year also opened up the worldwide bands to RVers and sailors wishing to put high-frequency, skywave communications in their vehicles and boats, and drive off or sail off to regions in the world without cell phone coverage, and still be able to stay in touch with friends back home. No longer would the General class code test at 13 wpm be the barrier for this worldwide license — at 5 wpm, the Morse Code speed is so slow that an applicant could actually write down the individual dots and dashes, and then go back and fill in the copy before their paperwork is graded. Code test guidelines by the volunteer examination coordinator system allow enough margin for error where 7 out of 10 correct answers about the copy you have written down means passing the Element 1 code exam at 5 wpm. You could also show 26 letters in a row copied correctly after the code test is over, and you even have a minute or so to go back and spruce up your 26 letters to insure the plain language text is all spelled correctly.

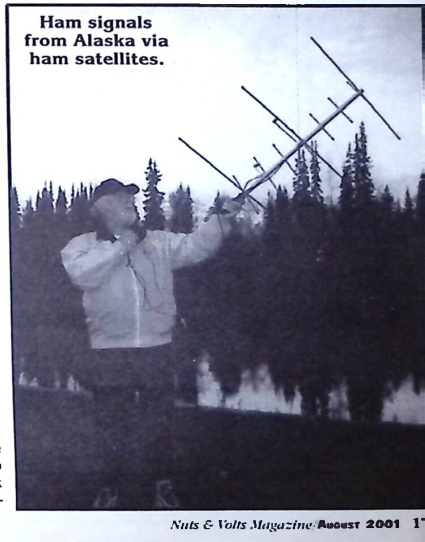
If you have learned the code by memory, but have a hearing deficiency that won't let you hear the difference between dots and dashes, there are still ways to get through the 5 wpm Morse Code exam. While there are no more waivers to get you out of the code test, Morse Code sending is an option, as well as the examiner starting and stopping code sending to help make up for your hearing handicap.

All amateur radio examinations are now conducted by three accredited volunteer examiners; and if you let them know in advance that you are coming with a doctor's statement about your hearing deficiency, they might be prepared to substitute a code-sending test as an alternate way for you to demonstrate to them that you have mastered the Morse Code to the best of your capability.

Even more good news about all amateur exams — there are no secret questions or multiple-choice answers on the test you will take.

Element 2 — Technician class
Element 3 — General class
Element 4 — Extra class
Element 1 — 5 wpm Morse Code

Study books written in a Q & A format with an explanation of each correct answer are available at any RadioShack store throughout the country, and at most amateur radio dealers. You can also double-check your study process by going to the fol-



The United Nations ham station in New York on the air.

Kids have fun with ham radio as part of Scouting.

lowing web sites and taking a sample ham radio test for either Technician, General, or Extra class:

- www.hamtest.com
- www.webexams.com
- www.qrz.com

Locating an examination session near you is easy by logging onto the American Radio Relay League (ARRL) web site at www.arrl.org/.

At the ARRL web page, you will find ham radio news bulletins, a ham radio hamfest calendar of weekend gatherings, your examination schedule, and some of the latest excitement out there on the airwaves. You can also receive by mail a big "welcome wagon" ham radio package containing everything you need to know to get started in your study by contacting the American Radio Relay League at 1-800-326-3942, or email to newham@arrl.org. This package will also list local examinations near where you live, as well as ham class schedules maybe only a few miles away.

ON THE AIR WITH HAM RADIO

There have been plenty of technological changes that have helped the ham radio service go from a slight decline to a major increase. An example of ham excitement is the International Space Station whose crew are almost always licensed as amateur operators in the sky. The Space Station operates in the automatic digital modes, so you might exchange messages with them on a computer hooked up to a tiny two-meter base station or mobile.

Imagine the thrill of being able to talk directly to an astronaut with a little handheld FM two-meter transceiver as they "just" happen to be passing overhead. The conversation may only last a maximum of nine minutes, but if the frequency is not crowded, a little three-watt handheld can be a real exciting space talker.

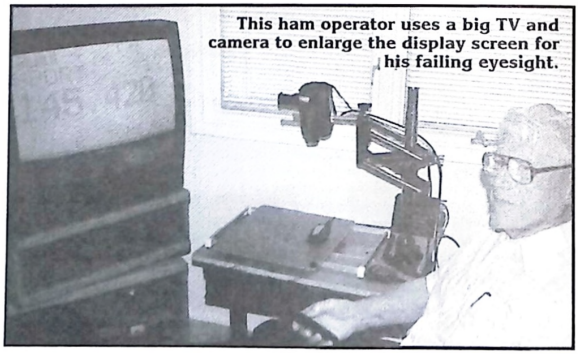
The astronauts regularly schedule ham communications with schools. On the ARRL web site, they may have a schedule of upcoming schools talking to the International Space Station, and directions on what it takes to get your local school on the air with the astronauts.

For sailors and RVers going to remote parts of the world where there is little commercial communications capability to the phone system, imagine the benefits of amateur radio out on the ocean tied into your computer, and sending and receiving free emails from your friends back home. And each time you may check into a mobile marine or RV mobile net, the net control station might log you onto a web site where friends can track your progress across the country, or across the oceans.

Amateur radio repeaters number in the thousands across the country, placed high on hills, mountain tops, and buildings to extend the range of low-power handheld transceivers. If you are into Scouting, there is just about nowhere in North America that you could go and not be able to make contact through a ham radio repeater to another station up to 100 miles away to call out for help, or just to say hello.

We also have low-earth-orbit space repeaters, too, making for exciting handheld contacts with other stations up to 1,500 miles away just by aiming a small two-band directional antenna up in the air as you track the spacecraft carrying ham radio (OSCAR) coming up from the horizon and a few minutes later disappearing over the horizon.

Here is a ham who listens to three radios at once in his vehicle.



This ham operator uses a big TV and camera to enlarge the display screen for his failing eyesight.

In rugged Alaska, this type of communication over ham frequencies is an everyday deal, with a couple of passes in the morning, and a couple of passes in the evening capable of extending your handheld range for thousands of miles back to the States.

The typical price for a two-meter ham radio handheld, also capable of tuning in weather and marine channels, is around $125.00 brand new. For a dual-band handheld covering two meters and the 440 MHz band, pricing is about $225.00. You could add a video communicator with any one of these handheld radios and send crystal-clear color images over the airwaves without needing to go to the internet.

For the worldwide bands, a larger ham radio transceiver (transmitter and receiver all in one nice, neat package) is available, new, for a little over $700.00. And for around $500.00, you could buy a small, low-power, battery-operated, worldwide ham set including the VHF and UHF bands, too, and set up on a mountain top or down at the lake, and let a solar charger keep your batteries on the air for hours at a time, chatting to the world on General class frequencies.

Ham operators can also send live NTSC television pictures over the UHF 430 MHz airwaves, ideal to back up disaster communications with a real live look at what is happening from a helicopter view in the sky. Many public safety agencies are quickly seeing how ham radio can serve them in times of emergency. Best of all, the ham operators come free.

More good news — pricing for amateur radio equipment has not increased over the last 10 years, and most equipment has almost doubled in the number of channels or bands it could operate. The features are up, with no additional increase in cost. Three of the largest amateur radio showroom/catalog sellers — Ham Radio Outlet, Amateur Electronics Supply, and Universal Radio — all report that ham sales are up, ham interest is high, and more and more newcomers are logging onto their web site to drool over all of the neat ham radio transceivers pictured and specked:

- www.universal-radio.com
- www.hamradio.com
- www.aesham.com

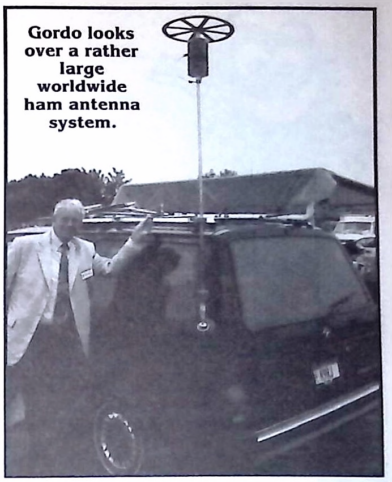
SO HOW DO I START?

Spend $12.00 for book #1, Technician class, at any RadioShack store, or on-the-web, or at a ham dealer. Begin reviewing the relatively easy Technician class question pool, and make contact with the League to follow up on where you might take your first entry-level test. You can also call 1-800-669-9594 and tell them you are ready to take a test in your neighborhood. They will ask for your zip code, and then tell you your local ham ambassador contact who will welcome you to a club test session, or a hamfest test session, or a local testing opportunity at their club ham station.

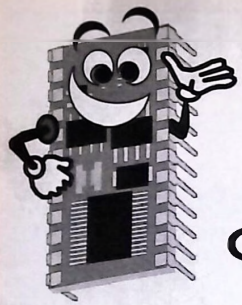
Then get on the air on the two-meter band, and make friends with hundreds of hams that will tell you about local club meetings, specialty clubs for your particular hobby in ham radio, a local ham radio hamfest gathering, and maybe some on-the-air nets where your two-meter signal gets tied into the Internet, and comes out somewhere in Europe on another ham radio system.

Yes, restructuring has made the amateur radio service more appealing than ever to kids, adults, and those ready to retire but not wanting to give up the gift of gab with other ham operators sharing the same interests. For sailors out on the high seas, ham radio may be their only radio lifeline for help in case of distress. For hikers, ham radio tied into a GPS may let someone else tell them exactly where in the world they are.

For me, I will enjoy working you over my radio system out on the airwaves. The new restructured ham radio — it is fun! Join us! **NV**



Gordo looks over a rather large worldwide ham antenna system.



by Jon Williams

Stamp Applications

CONTROL FROM THE COUCH

Putting the Spotlight on BASIC Stamp Projects, Hints, and Tips

Yep ... I'm a real man, alright. I live in the great state of Texas, I drink milk right out of the carton, I leave the toilet seat up and, of course ... I have five remotes to run the electronics in my entertainment center.

Since I've got all these remotes and one more – as they say here in the south – "ain't no big thang ..." I thought I'd play with decoding IR commands with a BASIC Stamp so that I could control more than the entertainment center from my couch. Now let me admit right up front that the code I'm presenting here is based on the work of one of my Parallax colleagues, Andy Lindsay. Andy is one of those incredibly enthusiastic guys who is like a bulldog when solving a problem and his enthusiasm is infectious – he's like the Pied Piper of hardcore Stamp programmers. Andy's done a lot of work with IR decoding and has created some really neat projects that use his techniques.

A few months ago, Andy showed me how easy it is to decode the Sony IR protocol with a standard Stamp 2. Easy, but consumes a fair chunk of variable space to do the decoding. What I thought I'd try to do is use the speed of the BS2sx and BS2p to do more detailed decoding while using fewer variables – a precious resource for the Stamp. Thankfully, it worked and I'm here to show you how. Our purpose, then, is to build a framework for IR remote control applications. What you control is up to you (I'll point to couple examples on the web to give you ideas).

IR (infrared) remotes have become as commonplace as pagers and cellular phones – they're everywhere and there is no escape. I actually have a small TV/VCR unit that has many functions that WON'T work without the remote. I know some of you (youngsters) are thinking, "Yeah ... so what, dude?" Well, there are more than a few of us that remember having to cross the room to adjust the volume or change the channel. Yes, the television stone age.

Understanding The Sony IR Protocol (SIRCS)

The Sony IR Control System protocol (SIRCS) is serial, but not like the serial signals we're accustomed to receiving with **SERIN**. The typical serial signal begins with a start bit then (usually) has eight data bits and one or two stop bits evenly spaced in the packet. The level of the bit determines its value.

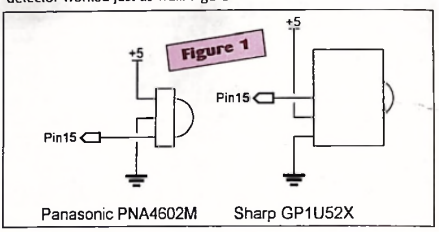
The Sony protocol is pulse coded; the width of a bit determines its value. The start bit is 2.4 mS wide, a zero bit is 0.6 mS wide, and a one bit is 1.2 mS wide. Every bit is followed by a rest period of 0.6 mS. There are 12 bits in the packet: the upper five for the device code, the lower seven for the unique command. (Note: Internet resources indicate that there are also 15- and 20-bit versions of the protocol that are beginning to appear in high-end television and video equipment.) When a key is held down, packets are repeated with a 20 to 30 mS break between them.

It should be clear by now that we can't use **SERIN** for this, so how are we going to read the Sony IR code?

Decode ... Decode ...

The idea is easy and so is the process. We're going to monitor the output of an IR detector and measure the width of output pulses. Lucky for us, the Stamp's **PULSIN** function is specifically designed for this purpose. Bit by bit, we'll build a packet. Once we find a start bit, we know that the next 12 bits are the meat of the packet and we can grab them. The BS2sx and BS2p are fast enough to decode the value of the last bit before the next one arrives (the BS2 isn't). This allows us to use just one word-sized variable to do pulse measurement (the BS2 requires a separate variable for each bit).

Hardware for IR detection is very simple: just connect an IR detector module to Vdd, Ground, and an available Stamp pin. I tested these programs with a 40 kHz detector (Sharp GP1U52X) from RadioShack (#276-137) and the 38 kHz detector (Panasonic PNA4602M) that is available from Parallax (#350-00014). The Sony specification is for 40 kHz modulation but I found that the 38 kHz detector worked just as well. Figure 1 shows the connections.



The Code ... The Code ...

Okay, then, let's make it work. The code in Listing 1 is a general-purpose Sony IR scanner. This program will monitor the IR detector output and display a code as it is received. The absence of a key is indicated by the constant value $FFF. This program has a repeat timer/counter so we can deal with a key that is being held down.

Take a look at the constants section first. You'll see the declarations StartWidth, Bit0Width, and Bit1Width. These may look a little funky considering the specifications we just talked about, so let me explain. The **PULSIN** function on the BS2sx measures the width of a pulse in 0.8 uS units. This means that we have to multiply the **PULSIN** result by 0.8 to convert it to microseconds. That's what we're doing here – just the other way around: we divide microseconds by 0.8 to get our expected result value. 2400 uS (2.4 ms) divided by 0.8 is 3000. So why is the start bit width for the BS2sx set to 2700?

In my experiments (with supplemental file IR_ANALYZE.BSX), I've found that every remote I tested outputs bits wider than the specification, but I didn't want to risk missing a start bit on a remote that may be tighter. So what I did is scaled back the start bit width by 10% (3000 x 0.9 = 2700). This width is far wider than the "1" bit

CONTROL FROM THE COUCH

spec (1500) so there is no danger of false triggering. Note that the **PULSIN** period for the BS2p is 0.75 uS. This accounts for the slight difference in constant values.

There's another important constant value, BitTest, that is actually calculated from the width of a zero bit. As we get into the heart of the code, you'll see that what we're actually going to do is look for ones. If a bit isn't one, it must be zero. Our test width is 150% of a zero bit and yet, still shorter than a "1." Let's go look at the Scan_IR subroutine to see how this works.

The routine starts by assuming a key isn't pressed and setting the irCode variable to $FFF (constant value NoKey). Then we wait for a start bit by using **PULSIN**. The output of the IR detector is active low, hence the IsLow (value = 0) declaration in the **PULSIN** function. The next line will cause the routine to terminate if no bit arrives before **PULSIN** times out (52 mS for the BS2sx). This line probably looks a little funny; using **BRANCH** with only one address. It's the same as

```
IF irStart = 0 THEN IR_Exit
```

but works a little faster. Speed is important in this routine.

If we do receive a pulse, it is checked by dividing it by the constant value, StartWidth. If the bit is a zero or one, dividing its width by the start bit width will return zero (remember that the Stamp uses integer math and division returns whole numbers) and the BRANCH command will force the program to look for another bit. When we do receive a start bit, the division will return one and we'll fall through the BRANCH and start collecting our data bits.

The next section works similarly: Measure a bit and calculate its value. We're using the value BitTest as our divisor here and BitTest is 150% of a zero bit. When we do receive a one bit (which is wider than BitTest), the division will return one, otherwise it returns zero. When you look at the (redundant) code that receives the bits, you may be tempted to put it into a loop and save a bit of typing. Don't ... it won't work. I know because I tried every trick in the book and a few that aren't. The timing overhead required to deal with a loop and variable indexing is just too slow and prevents decoding the packet properly.

Now that we have a decoded packet, let's go back to the main section of code and see what's happening.

The first thing we do is check to see if the key we just received is the same as the last one. If not, we'll clear the repeat timer and show the key value. The DEBUG output section will show the key value as three HEX digits and separated into its five-bit device code and seven-bit command code (the HEX values for these numbers are displayed on the next line).

When a key is held down, the program goes to Key_Timer before the display. If a valid key has been pressed, this section increments the key timer variable. What this does is let us control the key repeat rate. The actual rate is a function of the overall program loop timing multiplied by the KeyDelay constant value (which must always be greater than 0). In practice, we'd check to see that the keyRepeats value is zero before dealing with the key. A zero value means the key was just pressed or it has gone through the key repeat timing delay.

Figure 2 shows the output from the program when the VCR Fast Forward button is pressed. If you press a TV remote button, you'll get a device code of $01. The remote for my Sony video camera outputs a device code of $19 for VCR functions and $14 for camera functions

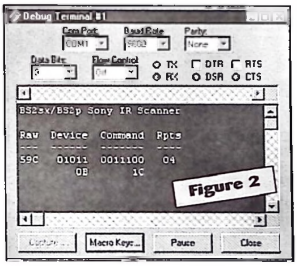


Figure 2

Going Remote

If you don't have a Sony (or compatible) remote, it's not a problem. Just pop into your local discount store and get one of the generic multifunction models. It'll cost somewhere between $5.00 and $10.00. You need to get a remote that lets you manually program it (by entering a manufacturer's device code). In our techno-phobic world of "I can't program my VCR ..." many remotes simply scan an internal table (while you're pointing it at the target device) until the device turns on or off. This won't work for us. I bought a Magnavox multi-function remote at WalMart for $9.00. It let me set the TV and VCR buttons for Sony products.

Interestingly, the VCR buttons (Play, Rewind, Fast Forward, etc.) still

```
' Listing 1
' Nuts & Volts, August 2001

' -----[ Title ]-----------------------------------------------------------
'
' File..... IR_SCAN12.BSX
' Purpose... IR Remote Scanner / Reporter
' Author.... Jon Williams (based on work by Andy Lindsay)
' E-mail.... jwilliams@parallaxinc.com
' Started... 23 MAR 2001
' Updated... 06 JUL 2001

' { $STAMP BS2sx }


' -----[ Program Description ]---------------------------------------------
'
' This program monitors an IR detector module and decodes the 12-bit Sony
' IR protocol (SIRCS).  When a key is detected, it's 12-bit code is
' displayed on the DEBUG screen and separated into device and command
' codes.
'
' No key pressed is indicated by code $FFF.
'
' Change the KeyDelay value to change the auto-repeat response.  The
' larger this value, the longer the delay repeats of the same key.


' -----[ Revision History ]------------------------------------------------
'
' 23 MAR 2001 : Original program developed for IR testing with BS2p
' 04 JUL 2001 : Improved IR scan routine to 12 bits
' 06 JUL 2001 : Improved display to show device and command codes


' -----[ I/O Definitions ]-------------------------------------------------
'
IR_pin  CON     15


' -----[ Constants ]-------------------------------------------------------
'
IsLow           CON     0
IsHigh          CON     1

NoKey           CON     $FFF            ' no IR key
KeyDelay CON    5                       ' loops for "new" key ( >0 )

StartWidth      CON     2700            ' width of IR start bit (BS2sx)
Bit0Width       CON     750             ' width of IR zero bit (BS2sx)
Bit1Width       CON     1500            ' widht of IR one bit (BS2sx)

'StartWidth     CON     2880            ' width of IR start bit (BS2p)
'Bit0Width      CON     800             ' width of IR zero bit (BS2p)
'Bit1Width      CON     1600            ' widht of IR one bit (BS2p)

BitTest         CON     Bit0Width * 3 / 2   ' test width -- look for 1's

LF              CON     10              ' linefeed character


' -----[ IR Codes ]-------------------------------------------------------
'
' Generic Sony IR remote codes (not a complete list)
'
IR_1            CON     $080
IR_2            CON     $081
IR_3            CON     $082
IR_4            CON     $083
IR_5            CON     $084
IR_6            CON     $085
IR_7            CON     $086
IR_8            CON     $087
IR_9            CON     $088
IR_0            CON     $089
IR_Enter CON    $08B

IR_ChUp         CON     $090
IR_ChDn         CON     $091
IR_VolUp CON    $092
IR_VolDn CON    $093
IR_Mute         CON     $094
IR_Power CON    $095


' -----[ Variables ]-------------------------------------------------------
'
irCode          VAR     Word            ' returned code
lastCode VAR    Word                    ' last returned code
irStart         VAR     Word            ' width or IR start bit
irBit           VAR     irStart         ' width of IR bit
keyRpts         VAR     Byte            ' repeats of current key

device          VAR     Byte            ' upper 5 bits of irCode
command         VAR     Byte            ' lower 7 bits of irCode


' -----[ EEPROM Data ]-----------------------------------------------------
'


' -----[ Initialization ]--------------------------------------------------
'
```

STAMP APPLICATIONS
CONTROL FROM THE COUCH

work when the remote is in TV mode. The device code of $0B indicates the VCR device. The device code is useful for keys that are common to both, like the channel changer and numeric keys. We can take advantage of the unique device code in our own projects.

Take A Number, Buddy

The first few IR control programs I wrote simply used the channel up and down buttons to change a program variable. Then I saw one of Andy's IR controlled BOE-Bots. Andy could tell the BOE-Bot — through the IR remote — how far to move. He entered the movement value using the remote's numeric keys. This was way too cool to ignore.

Listing 2 is my generic version of the numeric input, updated for the BS2sx and BS2p. Since this program only cares about numeric keys, we can ignore the device code in the packet and scale our input variables down to bytes. This saves a bit of variable space.

When the program runs, it asks you to press digits (up to some maximum) and then [Enter]. This program forces a key release by making the repeat rate very large. When the key timer value is something other than zero, the key is not processed. This code takes advantage of us having been conditioned by the operation of other remotes. If you do hold the key, it will eventually repeat. Human nature will cause you to release it and press again to repeat the digit.

Okay, let's analyze the heart of the program by starting with a valid number key. Since the key is not [Vol-] and not [Enter], the program will make its way to this line:

```
IrCode = irCode * 1 // 10
```

The purpose of this line is to "fix" the code alignment of the numeric keys. The "1" key has a code value of zero while the "0" key has a code value of nine. Adding one and taking the modulus (remainder of division) of 10 takes care of correcting the alignment. The value in irCode now matches the key that was pressed.

The key is displayed on screen and the user's value is updated. Since the user value is a decimal number, we shift the old digits left by multiplying by 10. Our new key is added after the shift to complete the update.

If we make an entry error, we can correct it by pressing the [Vol-] key. This key is used because it's typically a left-arrow key on the remote, just like the backspace key on a computer keyboard. When this key is pressed, the entry digit is erased by moving the screen cursor left with a backspace (8), then printing a space to remove the old digit, then printing another backspace to return the cursor to the correct spot. We also have to update the usrValue variable. This is a simple matter of dividing by 10 to get rid of the "ones" digit.

You may have noticed that I set the MaxDigits value to four. This code doesn't do any validity testing, so allowing a five-digit value could result in errors. To see for yourself, change MaxDigits to five, then enter the number 99,999. The entry area will show "99999," but the result in usrValue will be 34,463. The reason for this is that the maximum value of a 16-bit (word) variable is 65,535, so the usrValue gets truncated.

If you're interested in numeric input while still maintaining 12-bit code for device identification, download the supplemental file IR_NUMBER12.BSX.

It's Up To You Now

So what do you want to control? The sky is the limit. At the Embedded Systems Conference in April, Parallax had several demos that used IR control. I wrote the code for our neon sign (each letter was an individual neon tube and controller by a Stamp pin) and for a model train speed controller. You can find the code for these projects on the Parallax web site at this link:

www.parallaxinc.com/html_files/resources/esc2001.htm

Just keep in mind that code was written a few months ago and I've updated the BS2sx/BS2p IR input routine. If you're a BS2/BS2e user and are chomping at the bit (so to speak) to use an IR remote with your project, download the file "IR LED & 40 KHZ DETECTOR.PDF" from Parallax. This document was written by Andy and is full of great IR stuff for the BS2. You can find it at this link:

www.parallaxinc.com/html_files/resources/wknd_specials.htm

Happy Stamping — from across the room or otherwise. NV

Listing 1 Continued

```
Initialize:
  PAUSE 500
  DEBUG "BS2sx/BS2p Sony IR Scanner", CR, CR
  DEBUG "Raw  Device  Command  Rpts", CR
  DEBUG "---  ------  -------  ----", CR

'-----[ Main Code ]----------------------------------------------------------
'
Main:
  GOSUB Scan_IR                         ' check for IR key
  IF (irCode = lastCode) THEN Key_Timer ' key is being held
  keyRpts = 0                           ' not held, reset timer
  GOTO Show_Key

Key_Timer:
  IF (irCode = NoKey) THEN Show_Key     ' no key, skip timer
  keyRpts = keyRpts + 1 // KeyDelay     ' update the repeats timer

Show_Key:
  lastCode = irCode                     ' save last key

  device = irCode >> 7                  ' extract device code
  command = irCode & $7F                ' extract command

  DEBUG Home, LF, LF, LF, LF
  DEBUG HEX3 irCode," "
  DEBUG BIN5 device," ", BIN7 command, "   "
  DEBUG DEC2 keyRpts, CR
  DEBUG "          ", HEX2 device, "       ", HEX2 command

Loop_Pad:
  PAUSE 50                              ' pad loop timing
  GOTO Main


'-----[ Subroutines ]--------------------------------------------------------
'
' Receive and decode Sony IR command
'
Scan_IR:
  irCode = NoKey                        ' flag value

Wait_For_Start:                         ' wait for start bit
  PULSIN IR_pin,IsLow,irStart
  BRANCH irStart,[IR_Exit]              ' exit if no key down
  BRANCH irStart/StartWidth,[Wait_For_Start]

  ' This code MUST stay inline
  ' -- will NOT work in a loop

  PULSIN IR_pin,IsLow,irBit             ' decode 12 bits
  irCode.Bit0 = irBit/BitTest
  PULSIN IR_pin,IsLow,irBit
  irCode.Bit1 = irBit/BitTest
  PULSIN IR_pin,IsLow,irBit
  irCode.Bit2 = irBit/BitTest
  PULSIN IR_pin,IsLow,irBit
  irCode.Bit3 = irBit/BitTest
  PULSIN IR_pin,IsLow,irBit
  irCode.Bit4 = irBit/BitTest
  PULSIN IR_pin,IsLow,irBit
  irCode.Bit5 = irBit/BitTest
  PULSIN IR_pin,IsLow,irBit
  irCode.Bit6 = irBit/BitTest
  PULSIN IR_pin,IsLow,irBit
  irCode.Bit7 = irBit/BitTest
  PULSIN IR_pin,IsLow,irBit
  irCode.Bit8 = irBit/BitTest
  PULSIN IR_pin,IsLow,irBit
  irCode.Bit9 = irBit/BitTest
  PULSIN IR_pin,IsLow,irBit
  irCode.Bit10 = irBit/BitTest
  PULSIN IR_pin,IsLow,irBit
  irCode.Bit11 = irBit/BitTest

IR_Exit:
  RETURN
```

```
' Listing 2
' Nuts & Volts, August 2001

' -----[ Title ]-----------------------------------------------------
'
' File..... IR_NUMBER.BSX
' Purpose... Input Number from Sony IR remote
' Author.... Jon Williams (based on work by Andy Lindsay)
' E-mail.... jwilliams@parallaxinc.com
' Started... 04 JUL 2001
' Updated... 06 JUL 2001

' { $STAMP BS2sx }


' -----[ Program Description ]---------------------------------------
'
' This program accepts numeric input from a Sony IR remote.  This program
' uses only 7 bits (of 12 in the Sony protocol) for the IR code.
'
' Digits are entered from remote keypad.  The Volume-down [Vol-] key acts
' like a backspace key to correct mistakes.  Pressing [Enter] accepts the
' value.


' -----[ Revision History ]------------------------------------------
'
' 05 JUL 2001 : Version 1 tested and working
' 06 JUL 2001 : Added backspace editing


' -----[ I/O Definitions ]-------------------------------------------
'
IR_pin   CON     15


' -----[ Constants ]-------------------------------------------------
'
IsLow           CON     0
IsHigh          CON     1

NoKey           CON     $7F             ' no IR key
KeyDelay CON    50                      ' loops for "new" key ( >0 )

StartWidth      CON     2700            ' width of IR start bit (BS2sx)
Bit0Width       CON     750             ' width of IR zero bit (BS2sx)
Bit1Width       CON     1500            ' widht of IR one bit (BS2sx)

'StartWidth     CON     2880            ' width of IR start bit (BS2p)
'Bit0Width      CON     800             ' width of IR zero bit (BS2p)
'Bit1Width      CON     1600            ' widht of IR one bit (BS2p)

BitTest         CON     Bit0Width * 3 / 2  ' test width -- look for 1's

BS              CON     8               ' backspace character
MaxDigits       CON     4               ' width of input field


' -----[ IR Codes ]-------------------------------------------------
'
' Generic Sony IR remote codes (7-bit; not a complete list)
'
IR_1            CON     $00
IR_2            CON     $01
IR_3            CON     $02
IR_4            CON     $03
IR_5            CON     $04
IR_6            CON     $05
IR_7            CON     $06
IR_8            CON     $07
IR_9            CON     $08
IR_0            CON     $09
IR_Enter CON    $0B

IR_ChUp         CON     $10
IR_ChDn         CON     $11
IR_VolUp CON    $12
IR_VolDn CON    $13
IR_Mute         CON     $14
IR_Power CON    $15


' -----[ Variables ]-------------------------------------------------
'
irCode          VAR     Byte            ' returned code
lastCode VAR    Byte                    ' last returned code
irStart         VAR     Word            ' width or IR start bit
irBit           VAR     irStart         ' width of IR bit
keyRpts         VAR     Byte            ' repeats of current key

numDigits       VAR     Nib             ' digits entered
usrValue VAR    Word                    ' entered value


' -----[ EEPROM Data ]-----------------------------------------------
'
```

```
' -----[ Initialization ]-------------------------------------------
'
Initialize:
  numDigits = 0                         ' reset digits entered
  usrValue = 0                          ' clear old value

  PAUSE 500
  DEBUG CLS, "Press digits (up to ",DEC MaxDigits,"), then [Enter]: "


' -----[ Main Code ]------------------------------------------------
'
Main:
  GOSUB Scan_IR                                 ' check for IR key
  IF (irCode = lastCode) THEN Key_Timer         ' key is being held
  keyRpts = 0                                   ' not held, reset timer
  GOTO Check_Key

Key_Timer:
  IF (irCode = NoKey) THEN Check_Key            ' no key, skip timer
  keyRpts = keyRpts + 1  // KeyDelay            ' update the repeats
timer

Check_Key:
  lastCode = irCode                             ' save last key
  IF (irCode = NoKey) THEN Main                 ' no key, go get one
  IF (keyRpts > 0) THEN Main                    ' in repeat delay

Check_BS:
  IF (irCode <> IR_VolDn) THEN Check_Digit
  IF (numDigits = 0) THEN Main                  ' nothing to clear
  DEBUG BS," ",BS                               ' clear screen digit
  usrValue = usrValue / 10                      ' update user value
  numDigits = numDigits - 1                     ' update digit count
  GOTO Loop_Pad

Check_Digit:
  IF (irCode = IR_Enter) THEN Show_Value
  IF (numDigits = MaxDigits) THEN Main          ' no space for another
  IF (irCode > 9) THEN Main                     ' not a digit

  irCode = irCode + 1 // 10                     ' correct digit value
  DEBUG DEC1 irCode                             ' show digit on screen
  usrValue = usrValue * 10 + irCode             ' update user value
  numDigits = numDigits + 1                     ' update digit count

Loop_Pad:
  PAUSE 100                                     ' pad loop timing
  GOTO Main

Show_Value:
  IF (numDigits > 0) THEN Has_Value             ' check for actual entry
  DEBUG CR, CR, "No value entered."
  PAUSE 1500
  GOTO Initialize

Has_Value:
  DEBUG CR, CR, "Your value was ", DEC usrValue
  PAUSE 2500
  GOTO Initialize


' -----[ Subroutines ]-----------------------------------------------
'
' Receive and decode Sony IR command
' -- downsized to 7 bits
'
Scan_IR:
  irCode = NoKey                                ' flag value

Wait_For_Start:                                 ' wait for start bit
  PULSIN IR_pin,IsLow,irStart
  BRANCH irStart,[IR_Exit]                      ' exit if no key down
  BRANCH irStart/StartWidth,[Wait_For_Start]

  ' This code MUST stay inline
  ' -- will NOT work in a loop

  PULSIN IR_pin,IsLow,irBit                     ' decode 7 bits (command)
  irCode.Bit0 = irBit/BitTest
  PULSIN IR_pin,IsLow,irBit
  irCode.Bit1 = irBit/BitTest
  PULSIN IR_pin,IsLow,irBit
  irCode.Bit2 = irBit/BitTest
  PULSIN IR_pin,IsLow,irBit
  irCode.Bit3 = irBit/BitTest
  PULSIN IR_pin,IsLow,irBit
  irCode.Bit4 = irBit/BitTest
  PULSIN IR_pin,IsLow,irBit
  irCode.Bit5 = irBit/BitTest
  PULSIN IR_pin,IsLow,irBit
  irCode.Bit6 = irBit/BitTest
  PULSIN IR_pin,IsLow,irBit
  irCode.Bit7 = 0

IR_Exit:
  RETURN
```

by Robert Nansel

Amateur Robotics

This month, I'll continue the theme of self-education with capsule reviews of books useful to robot builders. This time, I'm going to cover books concerning biological models for robots. Most robot builders don't have a background in biology (I don't), so I've got some recommendations to help you along on your journey. I also have a review of a favorite book thrown in for fun, and I close with detailed instructions for stripping down the X-Y tables used in the Heavy Iron project.

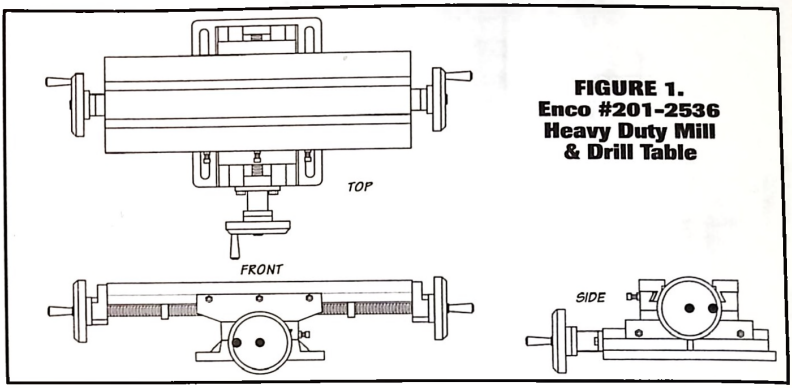


FIGURE 1. Enco #201-2536 Heavy Duty Mill & Drill Table

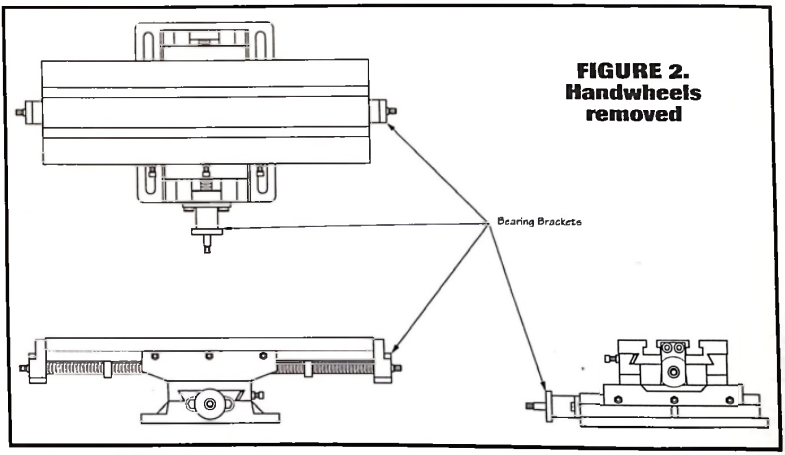


FIGURE 2. Handwheels removed

Robota Incognita

Robot builders are explorers on the margins of a vast, undiscovered country, a place that might be marked on maps as Robota Incognita.

Unlike other fields of technical exploration, in Robota Incognita amateurs and professionals start on more nearly equal footing. Professional robot builders have more money and specialized knowledge than most amateur robot builders, but compared to fields like nuclear physics or oceanography, the differences between professional and amateur are minor.

Amateur robot builders make up for being cash poor the way amateur explorers always have done: with dedication, frugality, and mutual assistance. But to bridge the second advantage the professionals enjoy — specialized knowledge — you must thoroughly educate yourself.

I don't mean you should quit your job and get a robotics engineering degree; most likely you already come from some sort of general engineering or technical background. With conscientious reading, you can gain what useful book knowledge there is on robotics. You still might lack the experience of building practical robots, though — robots that do something useful.

Only by building robots can you learn about robots. Because resources are always limited, you must gain the maximum knowledge you can from each robot you build. Not every robot will be successful, so you must build as many robots as you can.

Shoestring Robots

The first step is to build robots of graduated difficulty and capability, recording all details along the way so others can follow. Most important, like any explorer, you should record your personal journey to the frontier, even though it means at first describing territory already known. Lewis and Clark did it, and so must you.

You don't have to build a sequence of 20 radically different robots; rather you might build, say, 10 robots with only minor variations and successive refinements. Start with a simple robot, and document it with clear sketches and schematics. Add one improvement, and document that.

Or refine your robot by removing a subsystem and replacing it with a different or upgraded subsystem. For example, replace an IR range finder with an ultrasonic range finder. There are many details different between the two, but they share the same sort of output, namely a measure of range. From the start, design for subsystems to be swapped and upgraded. Your planned sequence of robots to build is your strategy for exploration.

What if experience with past robots (yours or others) tells you to incorporate a host of changes in your next robot? Rather than making a bunch of (possibly interacting) changes at once, you should take the most fundamental single change and build a new robot, the simplest one you can, around it. Then incorporate the rest as successive refinements one at a time.

What I've just described is disciplined engineering practice: keep a notebook, make one tweek at a time, learn from your mistakes. Educate yourself by your own disciplined effort to map the territory and make it your own.

Learning from Nature

The first and best teacher for designing mobile robots has always been nature. Most robot builders out there already derive inspiration from

Robotics

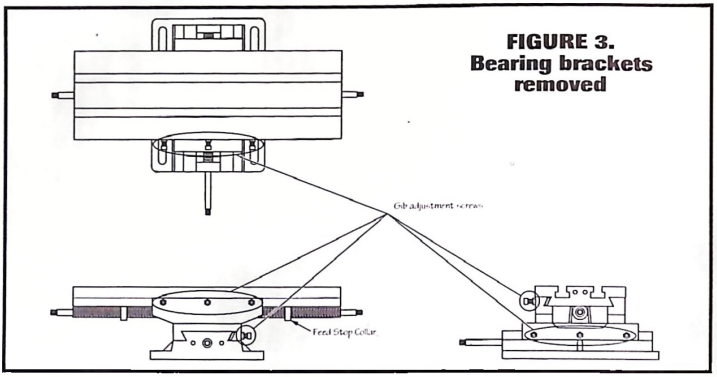


FIGURE 3. Bearing brackets removed

biological systems, even if it's only as vague as "I want my robot to be shy like a mouse" or "my robot should track the sun like a flower." Don't underestimate the value of such simple points of departure, but remember also there's a vast treasure trove of knowledge in the biological realm that can inform your design work. The trick is knowing how to exploit specialist areas of biomechanics, entomology, evolutionary biology, ethology, neuroanatomy, and even economics and political science.

If you are like me, your main expertise is not in any of the above fields. In college, I was too busy studying Laplace transforms and thermodynamics and electronics and programming to pay much attention to bugs — the creepy, crawly kind, not software variety. My knowledge of biological systems comes, therefore, purely from self study in the 15 years since college. I've learned a lot of value to robotics design, but it hasn't been easy. There's a whole different worldview between engineers and biologists, a different vocabulary and emphasis. Any time I've been able to find resources that help me translate biological arcana into nuts-and-bolts engineering, I've hung onto them, especially books aimed at the educated layperson.

If you've followed this column for a while, you know that I'm fascinated by insect locomotion, that of ants in particular, so the first two books I'll tell you about are about ants.

Journey to the Ants

In 1990, Bert Hölldobler and Edward O. Wilson published their epic monograph *The Ants* (Belknap Press of Harvard University Press, Cambridge, 1990): 732 pages of encyclopedic text, tables, and figures about myrmecology, the scientific study of ants. Though eminently readable (it won a Pulitzer), the book wasn't really intended for the general reader. It costs $90.00 for the oversize hardcover and weighs some 7.5 pounds, so it's not a book you would buy casually and read cover-to-cover. But if you want a detailed survey of the field of myrmecology, this is the book.

Most robot builders should at least know about the book, even though I can't recommend buying a copy. When it was first published, I was lucky enough to live near a library with a circulating copy, and I consulted it often. Check your local library; even if your library doesn't have it, odds are very good your librarian can get it for you through inter-library loan. You may have to wait a couple weeks, but it will be worthwhile. If you like the book and feel you must have you own copy, I commend you to a good used bookstore — who knows, you might get lucky and find a copy for, say, $45.00 US.

The book I do recommend buying, though, is *Journey to the Ants* (Belknap Press of Harvard University Press, Cambridge, 1994) by the same authors. If *The Ants* is the encyclopedia of myrmecology, *Journey to the Ants* is more a svelt travelogue; it is written in a crisp, confident style with a minimum of specialist jargon, and it positively shines with the author's love of

If you have suggestions, questions, or comments about amateur robotics topics, you can now reach me at:

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Ambridge, PA 15003

Email: bnansel@nauticom.net

their subject. It condenses the best of *The Ants* to a more manageable length, and at $17.00 US for the paperback, it won't kill your budget.

You'll find 15 chapters on every aspect of ant biology and behavior, starting with the author's personal journeys of study and ranging through an explanation of the amazing evolutionary success of ants to the intricate social organization and diverse habits of ant colonies. Best of all, there's a 16-page appendix on studying ants on your own, how to collect ants, to build and maintain habitats for them, and to observe their behaviors first hand. If you are like me, 10 minutes of informed observation of these fascinating creatures under a magnifying glass will send you to your notebooks to furiously scribble down ideas for many, many robots.

Ethology

Ants are relatively simple animals with a small repertoire of hard-wired behaviors; an individual ant foraging in the wild has, say, a two-week life span. An ant's preprogrammed behaviors work well in many circumstances, but not all, and eventually it will succumb to a situation for which it just wasn't programmed (robot builders are all too familiar with this aspect of robot behavior).

In the plural, ants achieve their supurb adaptability from the emergent behaviors of the social interactions of thousands of them. While robots can benefit from emulating the biomechanical capabilities of lone ants, the true power of emulating ants comes from emulating their social structures, and that means building lots of robots. Historically, few have had the money to build the dozens to hundreds of robots it would take to observe even rudimentary emergent behavior. That's just beginning to change as the cost of robotics drops and interest in the possibilities of emergence rises. Still, most amateur robot builders are mainly interested in working with one robot at a time.

For all their complex biology and behavior, ants are not the only animals worthy of study by robot builders. To gain a more general understanding of animal behavior, you should study Ethology — the study of what animals do, how and why they do it, and the evolutionary mechanisms responsible. An excellent introductory text on ethology is James L. Gould's *Ethology: The Mechanisms and Evolution of Behavior* (W.W. Norton & Company, New York, 1982).

I've heard Gould's book was one of the standard references at MIT's mobile robots lab in the 80s and thus indirectly helped inspire Rodney Brooks and his students to create their subsumption architecture robots. For me, the chapters on neural mechanisms were worth the price of the book, especially the sections on auditory processing and echo location in bats. I find *Ethology* to be an invaluable reference. Don't let the fact that it was first published in 1982 be a hindrance. The basics of ethology haven't changed much in 20 years. And you will certainly be able to find a used copy for a good price on the web (more on that later).

The Oxford Companion

The next on my list of recommended reference books is *The Oxford Companion to Animal Behavior*, edited by David McFarland (Oxford University Press, New York, 1981). *The Companion* is a series of over 200 articles on subjects concerning all aspects of the scientific study of animal behavior, including ethology, ecology, physiology, genetics, and psychology. Each article is a concise, standalone unit with numbered bibliographic references to further reading and cross-references to other articles within the book to reduce unnecessary duplication. *Companion* complements Gould's *Ethology* nicely, and it, too, was one of the references used at the MIT mobile robotics lab. The two books are a great start to any robot builder's biological reference library.

The best thing about *Companion* is that it is meant for the nonspecialist, and it assumes no previous background biological knowledge. All biological concepts prerequisite to understanding a given article are given. For instance, the article "Locomotion" — of particular interest to robot builders — deals with active and passive locomotion of every kind of animal whether moving in water, moving on the surface of water, moving on solid surfaces with legs or without legs, moving in trees, or moving underground. Flight is covered in a separate article, though a short comparison of the energetics of flight vs. running and swimming is given at the end of the locomotion article.

Say you want to build robot pets, there's the article "Household Pets," devoted to the subject of dogs and cats. Or, if you don't know what entry to look under but you know what animal you want to know about, there are two indexes in the back, one giving the English names of animals and the other their scientific names; each entry points to specific articles in which that animal is referenced. Ants, for instance, are listed under Alarm Responses, Parasitism, Tool Using, Territory, Pheromones, Orientation, and Symbiosis.

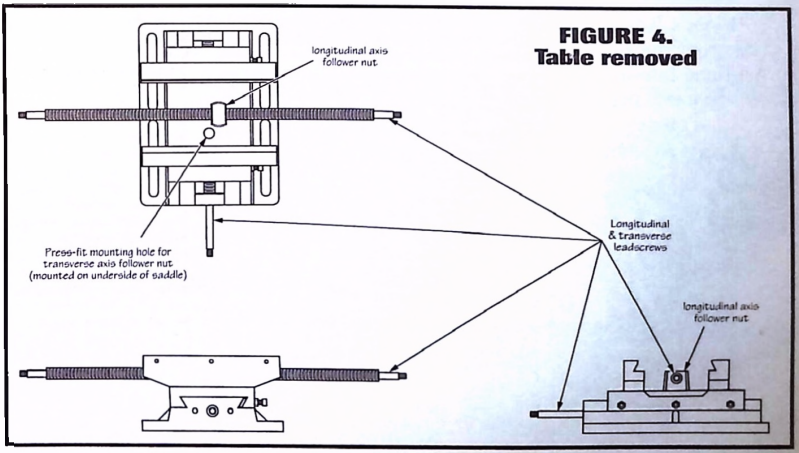

FIGURE 4. Table removed

Robotics

Building Your Library

I bought my copies of *Companion* and *Ethology* through the web, and I didn't have to pay a lot because I found them both used through the Advanced Book Exchange, a world-wide network of independent booksellers (www.abebooks.com). Think of A.B.E. as an Amazon.com for used and out-of-print books; it lets you search for books by author, title, publisher, edition, or ISBN. Heck, you can even find new books through A.B.E. — often at better prices than other online retailers.

Low prices aren't the only reasons to use A.B.E., though. First of all, I like to support independent booksellers because some books, whether they are out of print or are about offbeat or unfashionable topics, can only be gotten through used booksellers. Publishing is such a cutthroat business that books selling "only" in the thousands rather than millions don't stay in stock very long in the chain bookstores.

Second, a used book has a track record. Chances are you can get recommendations for used books because they've been around long enough for lots of people to have read them. Really good books don't go stale. Unfortunately, they do sometimes go out of print. So, save yourself some money and aggravation: buy used books whenever possible. You'll get great books and save some trees in the process.

Trustee from the Toolroom

While I ordinarily don't review fiction in this column, I have always drawn inspiration from the fiction I read, and sometimes that inspiration touches, if only indirectly, upon robotics. One such book is *Trustee from the Toolroom* by Nevil Shute (Queens House, reprint edition 1976). If you aren't familiar with Nevil Shute (the pen name of Nevil Shute Norway), a couple of his better-known books include *A Town Like Alice* and *On the Beach*. Shute was an engineer who only later in life became a novelist. He was also what the English term a "model engineer," what we in the the US would call a "home shop machinist." *Trustee* was his last book, and it was in the top 10 fiction bestsellers of 1960. It is also one of my favorites.

The book concerns Keith Stewart a gifted model engineer who writes a column for the fictitious magazine *Miniature Mechanic* (based on the British magazine *Model Engineer*, still published). Stewart makes a meager income from his column, but he loves the work. Despite how little money he makes, he maintains a faithful worldwide correspondence with fellow model engineers who are building his designs.

In the beginning, we learn that Stewart's sister Janice and her husband John Dermott, a retired Royal Navy Officer, are to sail their small boat from England around the world to western Canada, where they intend to emigrate. They are leaving their young daughter Janice in the care of the Stewarts during the trip. It's the late 1950s and postwar currency restrictions forbid them from taking enough money out of the UK to set up their new home. Unknown to Stewart, his sister and brother-in-law are going to attempt to smuggle their money out. They've converted their assets to diamonds and encased them in a box to be placed in the concrete ballast of their boat. As the novel opens, Stewart is brazing the box shut for them, though he's not aware of its contents.

The complication comes when the Dermotts' boat founders during their voyage on the rocks of a remote South Pacific island. Both are killed, leaving Keith Stewart as trustee to their estate and responsible for the welfare of young Janice. To Stewart's shock, rather than a comfortable inheritance, his niece is left with nothing. It then becomes his job to make his way around the world on almost no money — but with lots of help from his loyal readers — to recover the diamonds and somehow smuggle them back to England to restore his niece's inheritance.

Shute's characters are straightfoward people who do their utmost to make the best of things. Keith Stewart exemplifies the ideal of the resourceful engineer, a decent, humble, hardworking man who can build anything. Keith Stewart is some of what I aspire to as an amateur robot builder, columnist, and human being. Buy a cheap reading copy through abebooks.com and enjoy. Now a brief update on Heavy Iron.

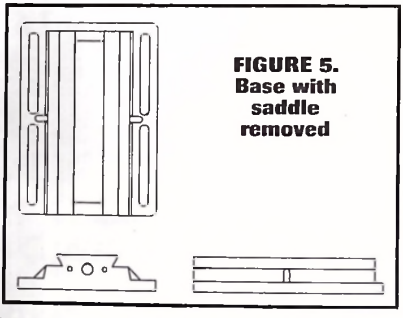

FIGURE 5. Base with saddle removed

Stripping the X-Y Tables

I'll start with the "large" table (Enco #201-2536) that will serve as the X- and Y-axes. Figures 1 through 5 show the process:

1) Remove the crank handles from the handwheels.

2) Loosen the setscrews on the handwheel locking collars and unscrew the collars. Remove the handwheels. Be sure not to lose the shaft keys that align the handwheels on the leadscrew shafts.

3) Use a 6mm hex wrench to remove the socket-head screws holding the longitudinal leadscrew bearing brackets to the table, and slide the brackets off the ends of the longitudinal leadscrew.

4) Loosen the longitudinal gib screw lock nuts and remove the gib adjustment screws. Slide the table out of the dovetail. Set the gib plate aside.

5) Loosen the setscrews on the feed stop collars, and remove the collars. Unscrew the leadscrew from the table.

6) Remove the two hex-head bolts from the transverse leadscrew bearing bracket, and slide the bracket off the transverse leadscrew shaft.

7) Unscrew the transverse leadscrew.

8) Remove the transverse gib as

Continued on Page 80

Ethology

Gould, James L., *Ethology: The Mechanisms and Evolution of Behavior* (W.W. Norton & Company, New York, 1982)
ISBN 0-393-01488-6 (hard)

Hölldobler, Bert and Wilson, Edward O., *Journey to the Ants* (Belknap Press of Harvard University Press, Cambridge, 1994)
ISBN 0-674-48525-4 (hard), 0-674-48526-2 (paper)

Hölldobler, Bert and Wilson, Edward O., *The Ants* (Belknap Press of Harvard University Press, Cambridge, 1990)
ISBN 0-674-04075-9 (hard)

McFarland, David, *The Oxford Companion to Animal Behavior* (Oxford University Press, New York, 1981)
ISBN 0-19-866120-7

For Fun

Shute, Nevil, *Trustee from the Toolroom* (Queens House, reprint edition 1976)
ISBN: 0892440163 (hard)

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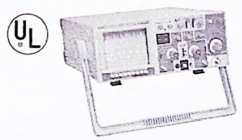

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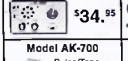

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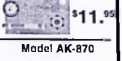

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ELECTRONICS Q & A

With TJ Byers

In this column, I answer questions about all aspects of electronics, including computer hardware, circuits, electronic theory, troubleshooting, and anything else of interest to the hobbyist.

Feel free to participate with your questions, as well as comments and suggestions.

You can reach me at:

TJBYERS@aol.com

or by snail mail at Nuts & Volts Magazine, 430 Princeland Ct., Corona, CA 92879.

What's Up:

Motors! Need a motor controller? Got 'em. Stepper motor overview. Putting motor and batteries to work in robots. And a full discussion of the batteries that power them. Finally, we revisit Ben Franklin and the current flow controversy.

Blame It On Ben

Q In the June 2001 column you said, "A source is an emitter of electrons and a sink is a collector of electrons, or a receptacle." Since electrons are negative this would make the negative (-) connection on the battery the source and the positive (+) the sink; TTL circuits would source electron current by grounding an output or sink electron current by driving toward Vcc. But he didn't ask about electrons, he asked about current. Electric current is opposite from the direction an electron moves in the circuit. Electric current is sourced from Vcc and sinks to ground.

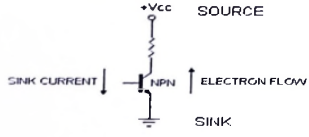
George Warner
via Internet

Q In your June Q&A column you discussed "sourcing" and "sinking" current relative to versions of the 555. I think I understand the terms, but also think that you have described them backwards! The ability of a device to source current refers to its ability to deliver current to a load which is usually grounded, while sinking current refers to its ability to receive current from a load which is typically connected to Vcc. To compound matters, in the "Shake It Baby" answer you have the ZSCT1555 "sourcing" base current to a 2N2222, which its spec sheet says that it will do very poorly. Am I all wet, or did you get up in a negative universe?

Michael
via Internet

A I knew when I answered this question there was going to be this kind of confusion and feedback. So let me try again. Source and sink have to do with conventional current flow, which — thanks to Ben Franklin when he "discovered" electricity after his wife told him to go fly a kite — forever flows from positive to negative. According to the conventional current flow theory, current flows from positive (source) to negative (sink), which is typically GND (ground). GND is the sink and the positive supply is the source. It wasn't until a hundred years later that scientists learned that electrons flow from negative to positive. But by then the positive to negative concept was deeply rooted in everything from batteries to motors to light bulbs. So this is why we have two different schools of thought: conventional current flow and electron flow. Here's a good rule of thumb: Follow the emitter arrow of the transistors, they point to the current sink.

As to sourcing the base of a 2N2222 transistor, yes Vcc is the source of the bias current in the circuit you mention. Fortunately, transistors are current amplifiers, so 100uA of base current turns into 10mA of collector current. As you can see, there is no violation of design or sourcing current rules here. Just FYI, the collector of this transistor, as shown in the drawing below, is the source and the emitter is the sink; the base is the control valve that — like a water faucet — determines how much source current is sinked.



Before I leave this subject, let me point out that wire colors often determine ground and power source. In electricity, like house wiring, ground (neutral) is always white, while the source (hot) is colored, usually black. In electronics, black wires are the ground (sink) — just the reverse — and a red wire is the positive (source).

Drill Motor Speed Control

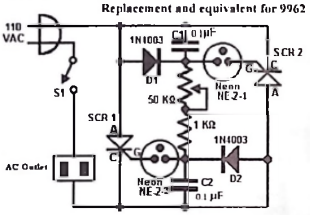
Q Would you by any chance have a good circuit for a heavy-duty speed control that I use with my 1/2 inch drill for the purpose of inserting a rod into the chuck and jacking up my 32-foot trailer jacks? Cost of the parts is no problem.

Stan
via Internet

A I can do better than that. I ran across a kit made by **Gibson Tech Ed (800-422-1100; www.gibsonteched.com)** — the K-019 speed controller — that does everything you want at an incredibly low $5.95. Gibson was kind enough to share the schematic with our readers.

MOTOR SPEED CONTROL KIT K-019

Replacement and equivalent for 9962



Battery Charger Basics

Q Your answer to Don Smith K6CHS in the Mar. 2001 issue was "use it." There is no mention of voltage: 1.5 volts for the AAs and 1.2 volts for the NiMH. How come?

Mitch
via Internet

A That's because the working voltages of a NiCd and NiMH battery are the same, 1.2 volts not 1.5 volts. But that's not the issue here because the charger is current driven, not voltage driven. So even if the charger were designed to charge a 1.5-volt battery, it will still work. How come?

The most common batteries in use today are NiCd, nickel-metal-hydride (NiMH), lithium-ion (Li-ion), and lead acid. NiCd and NiMH types require charging with a constant-current source. Current-source accuracy in these applications is generally not critical. Li-ion and lead-acid batteries require charging with a voltage-limited current source, and the charger for those types must include a timer that terminates the charge after a specified time interval. Here's what a typical NiCd/NiMH battery charger looks like.

Let's take a hypothetical NiCd battery charger with a +V of 10 volts and a 100mA charging current. The math tells us that the dynamic resistance of the current regulator is 88 ohms for a NiCd or NiMH cell. If the battery voltage was 1.5 volts, then the current regulator would adjust its dynamic resistance to 85 ohms.

R = +V - battery voltage / 0.1
R = 10 - 1.2 / 0.1
R = 88 ohms

As you can see, it's the charger and not the battery

voltage that changes the dynamic resistance of the current regulator. This is how one current regulator can automatically adjust to charging one cell or a stack of cells — the voltage isn't a factor, it's the current that does the charging.

Before I leave this subject, some of the cheap chargers use a fixed resistor instead of a current regulator. Still nothing changes except for a small difference in the charge current as cell voltage changes. In the example above, the charging current would decrease to 97mA with a 1.5-volt cell.

Finally: Charging at 0.1C standard rate for 14-16 hours will greatly enhance the NiMH battery's service life. Most NiMH batteries can withstand overcharge at a 0.1C rate indefinitely. This was the case for Mr. Smith. Charging rates above 1C can reduce battery life, and have to be monitored carefully for charge termination.

Alkaline Battery Charger Question

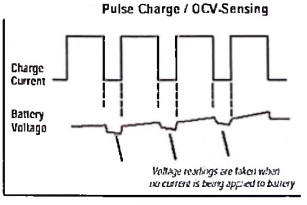
I have a Rayovac Power Station PS3 which is a charger for Rechargeable Alkaline™ Batteries. The user's guide also includes NiCd and NiMH. However, there is no provision for switching between the alkaline 1.5-volt and NiMH 1.2-volt mode, and I'm concerned about damaging my NiMH cells. I tried to charge them and they got quite hot after a couple of hours. They measured well above 1.2 volts, yet the indicator lights still showed an incomplete charge. I e-mailed the company and got an answer I'm not satisfied with — something about "conditioning." I would appreciate your opinion before I subject these to any further charges.

Mitch
via Internet

This is pretty much normal. NiMH batteries can reach as high as 130 degrees during a charge cycle. The amount of discharge and, of course, the rate of charge will affect this. The PS3 will charge your NiMH batteries just fine, as long as you match them cell for cell.

However, the PS3 charger isn't specifically designed for NiMH and will likely overcharge the battery, which is where the heat is coming from. So you have to monitor the charge yourself towards the end because the PS3 can't do it. You can monitor it for voltage or temperature. When the voltage across the NiMH battery starts to drop, it's charged. Alternatively, take its temperature using the back of your hand; when the battery is lukewarm, it's done.

Pulse Charge / OCV-Sensing



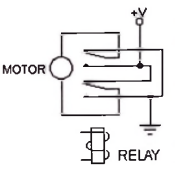
For the curious, the PS3 charger uses the pulse-current charge method. The amount of charge in the battery is determined by measuring its open-circuit voltage (OCV). The OCV is measured between the current pulses. If the cell's voltage is over 1.65 volts, the charge pulses are suspended until the OCV decreases. As the battery charge increases, the pulses remain off for a longer and longer period of time until the cell maintains a steady 1.65 volts — at which point the cell is fully charged. You'll find a schematic of the PS3 at **www.rayovac.com/business/oem/oem/specs/ren8g.shtml**.

H-Bridge Defined

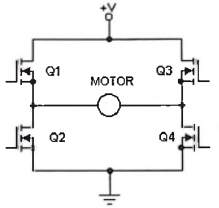
I have a 12-volt, 60-mA DC motor that I can reverse directions on using a DPDT relay with a five-volt coil (which I run from a different power source). I tried to use an H-bridge circuit to improve switching reliability, but now the motor turns at a very slow speed. I've tried a host of different driver transistors, including TIP41 and IRF511, but nothing seems to work the same way it did with the relay. I have carefully checked out the bridge circuit and find nothing wrong. Can you help me?

Joseph Lisinski
via Internet

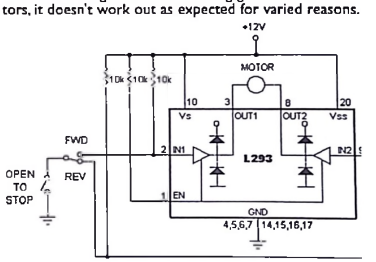
This is a common problem when trying to replace a DPDT switch or relay with H-bridge devices — and it's not the fault of the bridge, but often the way it's implemented. Let's first look at the way your reverse switch is presently wired.



In this configuration, the motor is placed across the common contacts of a DPDT relay. When the relay is de-energized, the top of the motor goes to GND (negative) and the bottom of the motor goes to V+. When the relay is energized, the contacts pull in, which places V+ on the top of the motor and GND on the bottom causing the motor to reverse direction. Now let's look at a typical H-bridge, which gets its name from its letter-like H appearance.



When Q1 is on, Q2 and Q3 are off, and Q4 is on. This places V+ on the left side of the motor and GND on the right side of the motor, which now rotates at full speed in one direction. To reverse the motor, Q1 and Q4 are turned off, and Q2 and Q3 are turned on. Sometimes when this arrangement is done using gates and transistors, it doesn't work out as expected for varied reasons.



Fortunately, there are several ICs that contain all these functions in one chip — like the L293 — which outputs up to 600mA at 36 volts. A motor reversing circuit using this IC is shown above. I've added an optional motor braking feature via the OPEN TO STOP switch. Unlike turning the power off and letting the motor freewheel to a stop, this switch applies a dynamic brake that uses the motor's back EMF to bring it to a fast stop. The L293 has two H-bridge circuits, so you can control a second motor if you wish. Or you can parallel the two H-bridges to increase the output current to 1.2 amps.

Stepper Motor Overview

Stepper motors are very confusing, or at least the stepper motor specs. I keep reading stuff like "hybrid" (as opposed to unipolar or bipolar). And then there is the famous statement: "Of course, this bipolar stepper motor can be driven as a unipolar motor, if desired." Well, I'm the first to admit that the "of course"

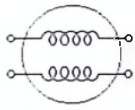
business ain't the least bit obvious to me! Sheesh. Any light you can shed on this would be most appreciated.

E. Nicholas Cupery
via Internet

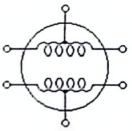
A This is a very large topic to take on in the space of this column, but I think I can make enough sense of it for your question. To begin with, hybrid is a type of stepper motor construction, not how the stepper operates. Basically, there are three different ways to build a stepper motor: variable reluctance, permanent magnet, and hybrid. The chart below highlights their differences.

Stepper Motor Type	Rotor	Stator	Coil Type
Variable reluctance	Iron vanes	Electromagnetic coils	Unipolar
Permanent Magnet	Magnets	Electromagnetic coils	Unipolar/Bipolar
Hybrid	Magnets	Magnets/coils	Unipolar/Bipolar

The terms unipolar and bipolar have to do with the coils associated with the stepper motors in the chart above. Bipolar stepper motors have just two coils with four wires. To operate the motor, the polarity of each coil must be changed in the same way you'd reverse the direction of a DC motor using a DPDT toggle switch, relay, or H-bridge (see "H-Bridge Defined" above). A unipolar motor also has two coils, but this time the coils are center-tapped, which results in six wires instead of four. The reason it's called unipolar is because you can tie the center tap high and alternately ground the ends of the coil to create the same effect as reversing the polarity across a bipolar (untapped) coil. Bipolar is two coils untapped; unipolar is two coils center-tapped. That's it!



BIPOLAR



UNIPOLAR

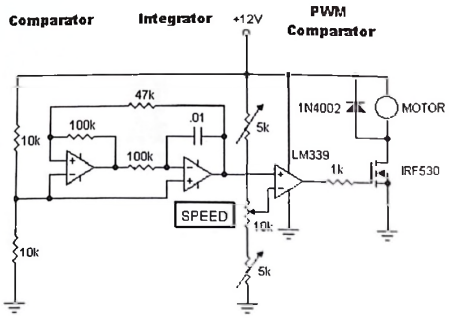
Now that you know that "hybrid" refers to motor construction, and has nothing to do with unipolar or bipolar, let's up the ante! You can mix and match construction types with coil types — to an extent. For example, you can have a hybrid motor with either a bipolar or a unipolar coil arrangement. Same with the permanent magnet stepper. Variable reluctance steppers, on the other hand, are unipolar only. To answer your final question, "Of course, this bipolar stepper motor can be driven as a unipolar motor ..." This refers to using a tapped coil as an untapped coil. That is, any tapped coil can be used in the bipolar mode by ignoring the tap. If the bipolar stepper has an unused tap, then it can be connected and operated in the unipolar mode. Of course, the unipolar stepper and the bipolar stepper require different controllers. Unipolar can work with half-bridge drivers while bipolar requires a full-bridge controller. Clear as mud, huh? Hope this helps.

Full Range Dimmer/Speed Controller

Q I need a 12-volt, 12-amp PWM motor speed control that lets the motor come to a dead stop when the speed control is wound all the way back. I could use a switch-pot to totally remove power, but wondered if there is a way to make the PWM control go from 0% to 100%. Most PWM controllers seem to go from around 5% to 95%.

Donald J. Johnson
via Internet

A You're quite right. Most motor speed controllers and lamp dimmers are built around a 555 timer that's operated in the PWM mode, which has a range of 5% to 95%. Before the 555 became popular, we used the circuit shown below.



This design uses a triangular wave generator and a comparator to create PWM (pulse-width modulation). It goes like this. Two op-amps use a positive feedback loop that's closed around a combined comparator and integrator. When power is applied, the comparator assumes one of two states; for the sake of this discussion, let's call it high. This output is applied to the integrator which begins to ramp down by charging the .01uF capacitor. When the output voltage of the integrator reaches a threshold voltage on the positive set by the 47k and 100k feedback resistors, the comparator switches from high to low which, in turn, causes the integrator to start charging the capacitor in the opposite direction. This cycle repeats endlessly and outputs a clean triangular waveform.

The triangular wave is applied to the positive input of the PWM comparator. The SPEED control sets the trigger point for this comparator. When threshold voltage is greater than the peak voltage of the triangular wave voltage, the duty cycle is 0%; when the threshold voltage is equal to the peak-to-peak triangular voltage, the duty cycle is 100%. The 5k trimmers are used to set the range of the SPEED control. Any op-amp will work in this circuit, including the ubiquitous 741. BTW, as an afternote here, I was pleased to find this design still live and well at **G. Forrest Cook's web site (www.solorb.com/gfc/elect/solarcirc/pwm1/)**.

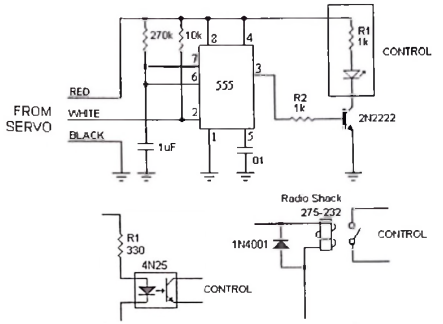
Robot Range Sensor

Q I am designing a robot to run outdoors, and would like to keep it on a leash so that it won't run out of my radio control range and into the street. My first thought was to detect my dog's radio fence buried under the ground, but for that I need a circuit that would detect the 10.65 kHz radio signal — which they sell by the collar for $79.00. So the question is, do you have such a circuit or is there a better way to find out when my bottie has run away from home, like maybe a simple short-range transmitter and receiver circuit?

Kerry Barlow
Kirkwood, NY

A. I thought about this long and hard, and discovered that few hobby bots are radio-controlled. Most are autonomous or tether-wired. And I doubt the electronic dog fence would work in all instances, especially if the bot has crossed over the line and is headed downhill at full speed with little room to stop. I also discovered that one thing a lot of bots have in common is a servo motor. Given the fact that you haven't started the design yet, this is the perfect pick-off point for an out-of-range signal.

Servos are actuated using a 20mS pulse that's sent at a rate of about 50 Hz. This signal is continuous and only stops when the receiver is out of range of the transmitter. So all it takes is a pulse detector circuit that sends a message to the bot's control circuitry when this signal disappears. Which is easily done using a 555 monostable multivibrator.



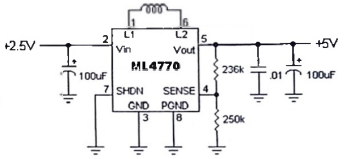
The 555 timer is adjusted to time out if there are no servo pulses after 300mS. I know, the time period of a 50-Hz wave is 20mS. But 300mS is fast enough for the bot to react to a signal loss (about 1/3 of a second), yet long enough to prevent a false alarm should the signal fade for a few cycles. The timer needs no power supply of its own; instead it splices into all three wires of the servo for its power and signal, normally in the color code indicated on the schematic. Well, that's the detector. I'm leaving it up to you to decide what to do with the control signal which is taken off the collector of the 2N2222; you'll see two choices at the bottom of the drawing.

Robot Needs More Voltage

Q. I have a small robot that runs off two NiCd cells. While this is plenty of voltage to power the drive motors, it's a couple of volts short of running the BASIC Stamp computer and IR sensors. I didn't wish to carry the added weight of, nor do I have the space for, two extra cells. However, when I looked at the National Semiconductor series of boost regulators, I discovered they all have a minimum input of 3.5 volts. Do you have a circuit that will work off 2.5 volts input and output five volts? I don't believe I need a lot of amperage out of the five-volt side. I think 300 mA would be sufficient for the Stamp and the little bit of additional TTL circuitry that I use.

Kerry Barlow
Kirkwood, NY

A. Yeah, the trend is toward lower rather than higher voltages. In fact, finding five-volt chips is getting progressively harder than finding 2.7-volt chips. So what to do? For the moment, the ML4770 from Fairchild (available from **Future/Active, 800-655-0006; www.future-active.com**) provides a solution. This "Two Cell, Adjustable Output, High Current Boost Regulator with Load Disconnect" chip provides a way of converting as low as 1.8 volts to between 3.0 and 5.5 volts at up to 800mA, depending on the input voltage (the higher the input voltage, the higher the output current; 400mA at three volts).



As a bonus, the chip is housed in a SOIC-SO8 surface-mount package — which goes a long way to reducing weight and PC board space. Critical to the ML4470's performance is the 10uH inductor. It must handle 1.5 amps of peak current without saturation and have no more than 100 milliohms of resistance. Fairchild recommends the Sumida CD54 or its equivalent from the list below.

Coilcraft — 847-639-6400
Coiltronics — 561-241-7876
Dale — 605-665-9301
Sumida — 847-956-0666

Whither the DTMF chips?

Q. I'll bet you can remember when the streets seemed to be paved with DTMF chips (both encoders and decoders). Geez, it couldn't have been more than a year ago, could it? Now, I cannot find any DTMF chips at all at my usual haunts (Jameco, Mouser, Digi-Key, etc.) Is there something strange going on in the industry? Surely DTMF cannot be passé!

Worse, of course, is the fact that I'm looking for stuff in DIP form. DIP is going the way of the Dodo bird — and fast. I don't think these tired old eyeballs of mine could handle soldering a bunch of surface-mount chips. Anyway, thanks for a good cry <g>. If you do happen to know what happened to all the DTMF stuff, I'd appreciate hearing about it.

E. Nicholas Cupery
via Internet

A. Let me take one problem at a time. Yes, most DTMF devices have faded into oblivion. That's because DTMF is becoming embedded via

Cool Web Sites

Have questions? These web sites have answers.

National Instruments' Intro to LabVIEW, a 40 minute course by National Instruments **http://www.techonline.com**

Anton Kruger offers a plethora of online resources relating to LED: theory, applications, and fun experiments.
http://tm0.com/sbct.cgi?s=118417869&i=325373&d=1284886

Electronics Q & A

DSP (digital signal processing) into controllers using software routines. This path leads to fewer hardware parts and higher reliability. Fortunately, they still make, or at least sell until stock runs out, DTMF chips. Here's a quick rundown; all four devices have a DIP footprint.

Digi-Key: TP5088N-ND (DTMF encoder)
Circuit Specialist: CD22204 (DTMF decoder)
JDR Microdevices: MC145436P (DTMF decoder)
Mouser: NTE1690 (DTMF encoder)

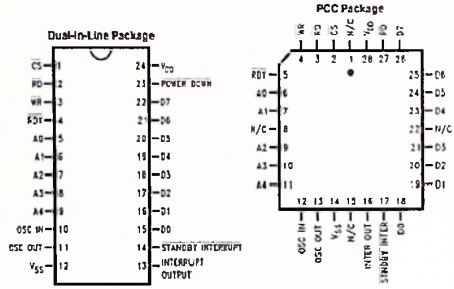
Now addressing your surface-mount device problem, I feel the same pain. My eyes aren't getting any sharper with age, and the fingers aren't as nimble. But I have a secret weapon. They are called SOT to DIP adapters, and are available from **Aries Electronics** (650 358-9559; www.larsenassociates.com/allprods.html) and **Brown Dog** (918-747-3874; www.brndog.com/SOT-23.html), among others.

Need A Datasheet!

Q I am in need of a pinout for the MM58167AN microprocessor real time clock.

Lawrence Patelunas
Langhorne, PA

A Here you are, courtesy of National Semiconductor (**www.national.com**).



You can find datasheets and pinouts for most ICs from **Questlink (www.questlink.com)** and **Free Trade Zone (www.freetradezone.com)**. Need a source for this chip? Here you go.

Digi-Key (800-344-4539; www.digikey.com)
Jameco (800-831-4242; www.jameco.com)
JDR Microdevices (800-538-5000; www.jdr.com/interact/default.asp)

MAILBAG

Dear TJ:

In your answer to Ed Schmidt in the June 2001 column, you gave a longish and lucid explanation for the workings of his tape deck's auto shutoff mechanism. But you didn't ask the one, vital question: Did his tape counter work? Most of the mechanisms I've seen (I've been a repair tech for years) are driven from the tape counter. Usually the only thing wrong is the belt (don't tell anyone I said so, but a small rubber band works fine, here.) About a 10 minute repair, assuming you can get to the thing. (I've a Technics deck sitting in the living room that had this exact malady.)

David W. Gray
via Internet

Events CALENDAR

AUGUST 2001

The Events Calendar is a free service for publicizing electronic events such as amateur radio hamfests, flea markets, etc. If your organization is sponsoring an event and would like a free listing, contact us at least 60 days in advance. Include your flyer, estimated attendance, name of the person to contact, and phone number.

Complimentary issues are available upon request for distribution to your attendees. A street address for UPS is required.

While we strive for accuracy in our calendar, we can not be responsible for errors or cancellations. The information contained in this column is for the use of the readers of *Nuts & Volts* and may not be republished in any form without the written permission of T & L Publications, Inc.

All listing information should be sent to:
Nuts & Volts Magazine
Events Calendar
430 Princeland Court
Corona, CA 92879
Phone 909-371-8497
Fax 909-371-3052
E-mail events@nutsvolts.com

August 3-4

TX - AUSTIN - Convention. Austin ARC, Austin Repeater Organization, & TX VHF-FM Society. Joe Makeever W5HS, 512-345-0800. Email: w5hs@arrl.net

August 4

IL - CARLINVILLE - Hamfest. Macoupin County Fairgrounds, Rt. 4 I-55 exit 60. 7am-12pm. Talkin: 146.82-. Macoupin County ARC, Tim Jones KA9VIV, 217-627-2355. Email: ka9viv@yahoo.com
MI - TAWAS - Hamfest. Iosco County AR Enthusiasts, John Hanley KA8AIP, 517-756-2845. Email: ka8aip@centurytel.net Web: http://www.oscoda.net/icare/
MO - SPRINGFIELD - Hamfest. University Plaza Trade Center. 8am-1pm. VE testing. Talkin: 146.910-. Southwest MO ARC, Woodie Moore WOODY, 417-833-2248. Email: w0ody@arrl.net Web: http://www.smarc.org
NY - ITHACA - Hamfest. Tompkins County Airport. 7am-2pm. VE exams. Talkin: 146.970-. Tompkins County ARC, Dave Flinn W2CFP, 607-533-4797. Email: dave@starflinn.com Web: http://www.compcenter.com/~tcarc
OH - COLUMBUS - Hamfest. Voice of Aladdin ARC, James Morton KB8KPJ, 614-846-7790. Email: kb8kpj@cs.com
PA - LEWISTOWN - Hamfest. Decatur Township Fire Co. Grounds. Talkin: 146.91. JVARC & Decatur Township Fire Co., Richard Yingling, 717-242-1882
VA - VINTON - Hamfest. William Byrd High School, Washington Ave. 9am-3pm. Talkin: 146.985 (-600). Roanoke Valley ARC, Dave Miller 540-977-3142. Email: dmiller@rev.net

August 4-5

WA - SPOKANE - Convention. Spokane RA, NW Tri-State ARO, Palouse Hills ARC, Inland Empire VHF Club, & Kamiak Butte, William Craze KC7YSF, 509-326-5353. Email: warchief@ccel.com

August 5

IN - ANGOLA - Hamfest. Land of Lakes ARC, Sharon Brown WD9DSP, 219-475-5879. Email: sharon.1.brown@gte.net
NY - WILLIAMSVILLE - Western NY Section Convention. Greater Buffalo Hamfest & Expo. Main Transit Fire Hall, 6777 Main St. Talkin: 147.255. Lancaster ARC, Luke Gallanno N2GDU, 716-634-4667. Email: luke@townecountryflorist.com Web: http://hamgate1.sunyerie.edu/~larc
VA - BERRYVILLE - Hamfest. Clarke County Ruritan Fairgrounds. VE exams. Talkin: 146.82-. The Shenandoah Valley ARC, Brian Mawhinney WB3FUM, 540-665-0761. Email: WB3FUM@arrl.net

August 11

IL - QUINCY - Hamfest. Western IL ARC, Bob Crockett N9KUT, 217-222-4467. Email: w9awe@arrl.org Web: http://www.qsl.net/w9awe
MD - WESTMINSTER - Hamfest. Reese Firemen's Carnival Grounds, Rt. 140. Carroll County ARC, Inc., email: k3pzn@arrl.net web: www.gis.net/~k3pzn
MI - JACKSON (VANDERCOOK LAKE) - Hamfest. Cascade ARS, Dennis Byrne KC8UZ, 517-522-4058. Email: byrneda@voyager.net Web: http://www.qsl.net/cars-jxn
NY - WESTMORELAND - Hamfest. Rome Radio Club, Russell Schorer KB2MAS, 315-853-8739. Email: kb2mas@gpoconnect.net
WA - LONGVIEW - Hamfest. Lower Columbia ARA, Bob Morehouse KB7ADO, 360-425-6076 after 6pm weekdays. Email: kb7ado@aol.com Web: http://www.qsl.net/nc7p/swapmeet.htm
WI - BARABOO - Swapfest. Sauk County Fairgrounds. 7am-12pm. VE testing. Yellow Thunder ARC, Steve Schulze N9UDO, 608-356-2313. Email: n9udo@arrl.net Web: http://www.qsl.net/ytarc/
WV - HUNTINGTON - Hamfest. Veterans Memorial Field House, 2590 5th Ave. 8:30am-2pm. VE testing. Talkin: 146.76-. TARA, Garry Ritchie W8OI, 304-733-1300. Email: tara@hams@juno.com Web: www.qsl.net/tara

August 12

CA - GOLETA (SANTA BARBARA) - Hamfest. Santa Barbara ARC, Alan Soenke WA6VNN, 805-562-2694. Email: ajsoenke@aol.com Web: http://www.sbarc.org
IA - AMANA - Hamfest. Cedar Valley ARC, Chuck Bassett N0OUTS, 319-378-0448. Email: n0outs@rf.org Web: http://cvarc.rf.org/
IL - PEOTONE - Hamfest. Will County Fairgrounds. 6am-3pm. Talkin: 146.52 simplex, 146.64 (-107.2). Hamfesters RC, Inc., Robert Nelson WB9WFR, 708-756-7984. Email: wb9wfr@aol.com
IN - GREENTOWN - Hamfest. Lions Club Fairgrounds. 8am-1pm. VE testing. Talkin: 146.91 & 146.79. Kokomo & Grant County ARCs, L. B. Nickerson K9NQW, 765-668-4814. Email: k9nqw@skyenet.net Web: http://www.netusa1/~ka6nqwnick/hamfest.html
KY - LEXINGTON - Hamfest. National Guard Armory adjacent to airport. 8am-4pm. VE sessions. Talkin: 146.760-. Bluegrass ARS, John Barnes KS4GL, 859-253-1178. Email: ks4gl@juno.com Web: http://www.BluegrassARS.org/
MN - ST. JOSEPH - Hamfest. St. Cloud ARC, Jack Maus WOMBD, 320-685-8295. Email: w0mbd@arrl.net Web: www.w0sv.org
NJ - BAYVILLE - Hamfest. Jersey Shore ARS, Ed Genoino WA2NDA, 609-971-2792. Email: wa2nda@aol.com Web: http://www.jsars.org
PA - MATAMORAS - Hamfest. Matamoras Airport Park, off Exit 53, I-84. Talkin: 146.760 -600, 100 Hz PL, 145.350 -600, 100 Hz PL. Tri-State ARA, Carl Will KB3DHN, 570-828-7622. Email: kb3dhn@mercurylink.net Web: http://www.qsl.net/k3tsa/
PA - SHREWSBURY - Hamfest. Shrewsbury Firehouse. VE testing. Talkin: 146.700. Southern PA Group, Hilltop Transmitting Assn., & York White Rose ARC, John Salony 717-741-1780. Cecil Mundorff 717-927-6662. Web: www.carli-online.com/hamfest

August 18

KS - CHANUTE - Hamfest. Chanute Area ARC, Charlie Ward WDOAKU, 316-431-6402
NJ - OAKLAND - Hamfest. American Legion Hall, 65 Oak St. Talkin: 147.49 in, 146.49 out. Ramapo Mountain ARC, Steven Oliphant N2KBD, 973-962-4584. Email: rmarc@qsl.net Web: http://www.qsl.net/rmarc
OH - FRIENDSHIP - Hamfest. Portsmouth Radio Club, Jack King KB8NBI, 704-372-5811

August 18-19

AL - HUNTSVILLE - Convention. Huntsville Hamfest Assn., Don Tunstill W4NO, 256-536-3904. Email: dtunstil@hiwaay.net

August 19

CO - GOLDEN - Convention. The Denver Radio Club, Ron Taylor K0HRT, 303-989-3978. Email: k0hrt@arrl.net Web: http://www.qsl.net/w0tx
IN - LAFAYETTE - Hamfest. Tippecanoe County Fairgrounds. 8am-2pm. VE exams. Talkin: 147.135+ & 443.775+ PL 88.5. Tippecanoe ARA, David Dull WB9BRX, 765-743-8305. Email: dave@dullville.com Web: www.w9reg.org
KS - SALINA - Hamfest. Central Kansas ARC, Ron Tremblay WA0PSF, 785-827-8149. Email: rtremblay@midusa.net
MA - CAMBRIDGE - Hamfest. MIT Radio Society/Harvard Wireless Club/MIT UHF Repeater Assn., Steve Finberg W1GSL. email: w1gsl@mit.edu (Nick Altenbernd KA1MQX, 617-253-3776 9am-5pm.) Web: http://web.mit.edu/w1mx/www/swapfest.html
NJ - MULLICA HILL - Hamfest. Gloucester County ARC, Harry Bryant AA2WN, 856-478-4738 Email: hbryant@excelonline.com Web: http://www.gcarc-w2mmd.org
OH - WARREN - Hamfest. Warren ARA, Renee McCaman KB8SVF, 330-847-8478. Email: mccaman@cboss.com Web: http://www.onecom.net/wara

August 25

FL - TAMPA - Hamfest. TARC Club House, right next to ball field. 8am-1pm. Talkin: 147.105+. Tampa ARC, Biff Craine K4LAW, 813-265-4812. Email: k4law@arrl.net Web: http://www.hamclub.org
IN - LAPORTE - Hamfest. LaPorte County Fairgrounds, St. Rd. 2 West. 7am-1pm. Talkin: 146.52, 146.61-, PL 131.8. LPARC, Neil Straub W29N, 219-324-7525. Email: nstraub@niia.net Web: www.geocities.com/K9JSI
MO - COLUMBIA - MO State Convention/CMRA Hamfest. National Guard Armory, Hwy 63. Central MO RA, Dale Huffington AE0S, 573-875-6170. Email: dale@tranquility.net Web: www.qsl.net/cmra/hamfest2001.htm
NY - MARGARETVILLE - Hamfest. Margaretville ARC, Lester Bourke KB2DCE, 845-586-2324. Email: bourke@catskill.net Web: http://www.catskill.net/marc
TX - GAINESVILLE - Hamfest. Cook County ARC, James Floyd N5ZPU, 940-668-7511. Email: jfloyd@cooke.net
WV - WESTON - Hamfest. WV State ARC, Ann Rinehart KA8ZGY, 304-768-9534. Email: ka8zgy@arrl.net Web: http://www.qsl.net/wvsarc

August 25-26

NM - RIO RANCHO - State Convention. Marcus Lieberman KM5EH, 505-836-1724. Email: km5eh@arrl.net Web: http://www.qsl.net/dchf

August 26

IL - DANVILLE - Hamfest. Vermilion County ARA Communications Center, Harrison Park West Addition, off I-74. VE testing. Talkin: 146.820 (-600). VCARA, email: VCARA@Talk.to

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Web: ncshows.com

Peter Trapp Computer Shows
603-272-5008
Web: www.petertrapp.com

Web: http://www.hamfest.org

Events CALENDAR

IL - JOLIET - Hamfest. Bolingbrook ARS, Thomas Ballard N9LIY, 630-739-3740. Email: th1303@mediaone.net Web: http://geocities.com/k9bar/
MO - ST. CHARLES - Hamfest. VFW Hall, 66 VFW Ln. 6:30am-1pm. VE testing. Talkin: 146.670-. St. Charles ARC, Kenneth Fieser KB0VLN, 314-428-4383. Email: kfieser@aol.com Web: http://www.qth.com/wb0hsi/
NY - YONKERS - Hamfest. Yonkers ARC, Tommy Monzon W5ACT, 914-533-2892 or 203-794-2665. Email: w5act@arrl.net Web: http://www.yarc.org
PA - NEW KENSINGTON - Hamfest. Skyview Radio Society, Robert Livrone N3WAV, 724-339-9607. Email: n3wav@arrl.net Web: http://www.micr oconnect.net/~ggross/skyview.htm
TN - LEBANON - Hamfest. Short Mountain Repeater Club, Roger Hughes W4IV, 615-893-5623

SEPTEMBER 2001

September 1

CA - VACAVILLE - Hamfest. Vaca Valley RC & Western States Weak Signal Society, Larry Hogue W6QMF, 707-452-9701. Email: w6qmf@cwnet.com
CANADA - ON - OTTAWA (CARP) - Hamfest. Ottawa ARC, Greg Danyichenko VE3YTZ, 613-236-9291. Email: fleamarket@oarc.net Web: http://oarc.net/fleamarket
NM - ALAMOGORDO - Hamfest. Alamogordo ARC, June Richmond K5BHE, 505-437-0298. Email: k5lrw@zlanet.com Web: http://www.zlanet.com/AARC/

September 1-2

CT - ENFIELD - Conference. Eastern VHF/UHF Society & North East Weak Signal. Bruce Wood N2LIV, 631-265-1015. Email: bdwood@erols.com
NC - SHELBY - Hamfest. Shelby ARC, John Ledford W4JL, 704-482-4507. Email: w4jl@shelby.net Web: http://www.shelby.net/n4fan

September 7-8

AR - MENA - Hamfest. Queen Wilhelmina State Park. 7am-5pm both days. VE testing. Queen Wilhelmina Hamfest Assn., Charlotte Lee KC5DOR, 870-642-7656 home or 870-642-2234 ext. 107 work. Email: clee1948@yahoo.com

September 7-8-9

CA - RIVERSIDE - Convention. Inland Empire Council of AR Organizations, Judy Ann Lowman W6YBS, 909-941-2367 or 909-862-1886. Email: w6ybs@juno.com
WY - LARAMIE - Hamfest. Campbell County ARC, Jay Ostrem W7CW, 307-682-7839. Email: w7cw@arrl.net Web: http://www.w7cw.vcn.com

September 8

FL - MELBOURNE - Hamfest. Platinum Coast ARS, Joe Mitchell K4AW, 321-723-1105. Email: hamfest@pcars.org Web: http://www.pcars.org
IN - SPENCER - Hamfest. Owen County ARA & Bloomington ARC, Millard Qualls K9DIY, 812-332-0074. Email: w9inl@arrl.net Web: http://www.bloomingtonradio.org
KY - LOUISVILLE - Convention. Bullitt County Fairgrounds, Greater Louisville Hamfest Assn., Herbert Rowe W4WQD, 812-294-4905. Email: wd4ixl@juno.com Web: http://www.thepoint.net/~glha
MI - GRAYLING - Hamfest. ARA of Hansen Hills. Jon Schultz N8YSS, 517-348-4966. Email: jschultz@izk.net Web: http://www.arahh.org/swapshop.html
MN - RUSH CITY - Hamfest. East Central Minnesota ARC, Larry Jilek KA0MEN, 320-358-4205. Email: lj@ecenet.com
NY - BALLSTON SPA - Hamfest. Saratoga County Fairgrounds. 7am-3pm. VE testing. Talkin: 146.40/147.00, 147.84/147.24. Saratoga County RACES, Darlene Lake N2XQG, 518-587-2385
PA - BARTONSVILLE - Hamfest. Eastern PA ARA & Pocono ARK, Jerry Truax N3SEI, 570-620-9080. Email: n3sei@arrl.net
WA - GRAHAM - Hamfest. Radio Club of Tacoma, Lou Simmons KB7WDB, 253-847-5124. Email: kb7wdb@juno.com Web: http://www.w7dk.org

September 9

MA - ORANGE - Hamfest. Mohawk ARC, John Dould AE1B, 978-249-5905. Email: ae1b@gis.net
MA - SOUTH DARTMOUTH - Hamfest. Southeastern MA ARA, Tim Smith N1TI, 508-758-3680. Email: rt_smith@yahoo.com
NY - BETHPAGE - Hamfest. Long Island Mobile ARC, Ed Muro K2EPM, 516-520-9311. Email: hamfest@limarc.org Web: http://www.limarc.org
OH - FINDLAY - Hamfest. Findlay ARC, Bill Kelsey N8ET, 419-423-4604. Email: kanga@bright.net Web: http://www.bright.net/~kanga/w8ft/hamfest.html
PA - BUTLER - Western PA Section Convention. Farm Showgrounds, Roe Airport. 8am-4pm. Talkin: 147.36+. Butler County ARA, Kevin Berry KF4RMA, 724-586-1182. Email: kf4rma@arrl.net Web: http://www.qsl.net/w3udx/

September 14-15

AL - MOBILE - Hamfest. Mobile ARC, Larry Early WB4YOR, 334-342-7601. Web: http://www.angelfire.com/al/marc3

September 14-15-16

IL - PEORIA - IL State Convention. Exposition Gardens. Fri: 3pm-dark, Commercial Bldgs., Sat: 8am-4:30pm, Sun: 8am-3pm. Gates open 6am Sat & Sun. FCC testing. Talkin: 147.075+. Peoria ARC, email: w9uvl@arrl.net Web: www.w9uvl.org

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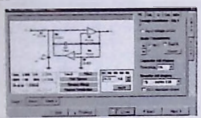

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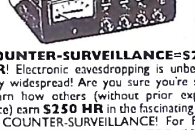

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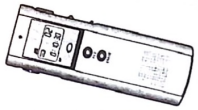

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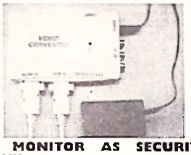

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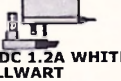

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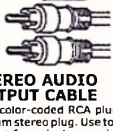

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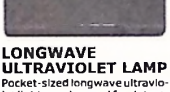

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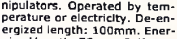

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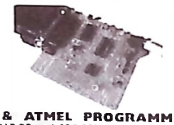

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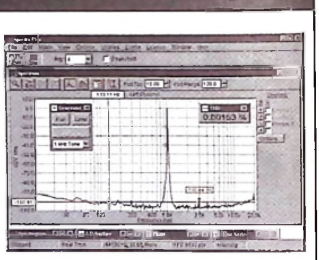

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Getting started with the AVR

by James Cart

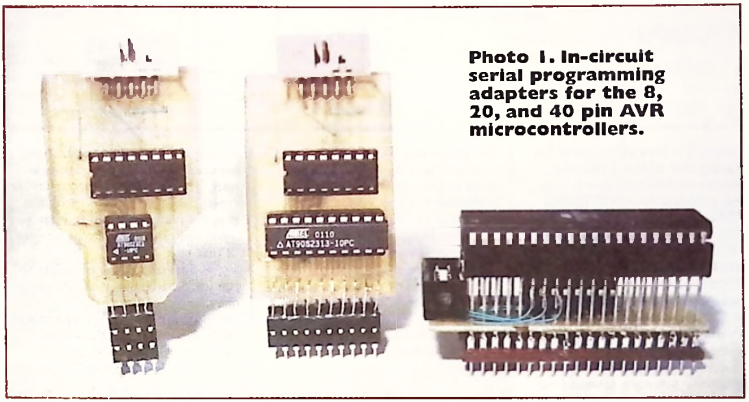


Photo 1. In-circuit serial programming adapters for the 8, 20, and 40 pin AVR microcontrollers.

Even if this is your first issue of *Nuts & Volts*, you're bound to find some useful information about Microchip's PIC microprocessors. These popular little RISC microprocessors offer excellent benefits for hobby and commercial applications alike.

PICs have plenty of competition from other RISC chips that offer similar benefits. This article is intended to help you find Basic language software, and build low-cost tools for the "other" RISC chip — the Atmel AVR.

Internals

The AVR is blazing fast, executing most instructions in one clock cycle. With a 4 MHz crystal, the AVR could execute close to four million instructions per second. Atmel offers 4 and 10 MHz versions. Most AVR chips support 118 instructions; many are optimized for use with "C" programming language.

Most AVRs have flash program memory. All have EEPROM data memory that can be programmed internally or externally at program time. Most chips have on-board RAM and 32 general-purpose I/O registers.

All AVRs are in-system programmable. Some have on-board UART for serial communication, analog comparator, or multi-channel analog-to-digital converters. The pulse-width-modulator function is great for motor controls, generating wave forms such as DTMF phone dialer.

Atmel conveniently designed the 8515's pin placement to be compatible with the pins on the 8051 microcontroller, making upgrades of old projects a lot easier. With the in-circuit-programming adapter described here, one can use inexpensive 8051 experimenter boards with the AVR8515. AVR pins can sink 20 mA, so they can drive LEDs directly.

One or two programmable timers and a watchdog timer round out the AVR's features. This is just a quick glance at the solid hardware of this product. The speed this chip offers makes it a lot more practical to use slower running languages, like BASIC, in applications requiring fast software.

The AVR is blazing fast, executing most instructions in one clock cycle.

Software Tools

Working with any microprocessor requires software tools. These tools include simulators for testing your code before programming the microcontroller. Assemblers are used for writing fast assembly language code, and software compilers are used with high-level languages such as Basic, C language, and others. The compiler and assembler may require a separate text editor or it may be integrated with other software tools. The level of integration usually increases with cost; there are exceptions, though. Of course, more costly packages have advanced features to make your programming life easier.

All the required software can be found free or at low cost on the web. With some easy-to-build programming adapters, even the very frugal can get started with the AVR.

Hardware Tools

All microcontrollers require a programmer of some kind. With the advent of In-Circuit Serial Programming (ISP) of micros, the programmer has been reduced to a few small parts and the right software. This type of programmer is all we need to program the AVR. There are several web sites listed in the Web Sources sidebar on this topic. Atmel also provides schematics and software.

Of course, there are other useful, but more costly, hardware tools. An In-Circuit Emulator (ICE) is awesome, if you can afford it. Alternatively, one could get an In-Circuit Debugger (ICD) if your processor supports that. The AVR does not support ICDs. These options are getting less costly. They can be necessary tools for big projects, but you can still get a lot done with Basic and an ISP.

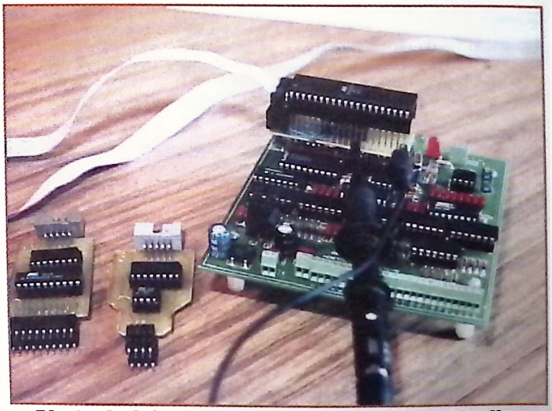
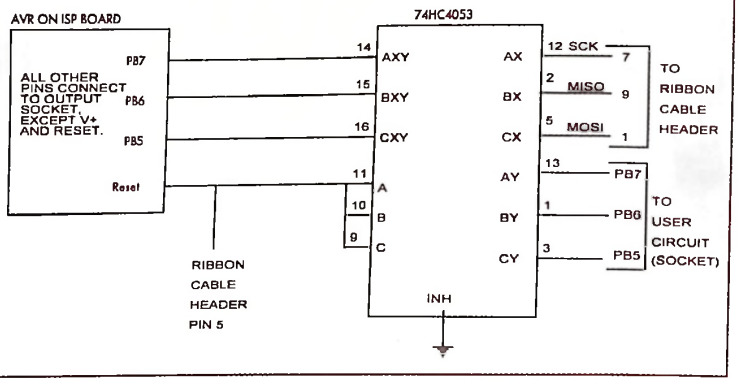


Photo 2. A board with an 8051 microcontroller being upgraded to the AVR8515.

AVR ISP PROGRAMMING ADAPTER — FIGURE 1



Bunches of Basic

A decent low-cost language is the Bascom Basic compiler by MCS Electronics. Their software integrates a text editor, compiler, simulator, and programming software in one package. The demo version does everything the full product does except it's limited to compiling 4,000 bytes of program code. The 20-pin AT90S2313 has a 2,000-byte program memory — perfect fit.

The built-in simulator lets you test your program before writing it to the uP. You can watch variables, step through the program one line at a time, or run to a specific line.

Another convenient feature is the hardware emulator for the LCD display and hardware I/O ports. The LCD emulator even emulates custom-designed characters.

When you are done with the simulator, it is time to program the chip using one of the supported programmer drivers. There is integrated software for the STK200, STK300 programmers, Dontronics DT006 SimmStick, and others.

Bascom also has special commands for LCD-displays, I2C chips, and 1WIRE chips. There is an integrated terminal emulator with download option. The full program only costs $69.00, with online ordering.

I did have a problem with the programmer software. It would not recognize the 2343 or the 2323 correctly, therefore it would not program those chips. I was able to work around the problem by using the AVR-ISP software to flash program the HEX code generated by BasComAVR. This required a few extra clicks of the mouse, but it worked fine.

Perhaps the best thing about Bascom is the email list. This is an excellent, web-based email forum to ask questions and learn about Bascom from the other Bascom users on the list. Code examples, compiler updates, and general comments about Bascom, the AVR, and 8051 micros are "on topic" for this list. Check the sidebar for their web site.

Another free basic compiler is a "work in progress." The JAVRbasic compiler is not fully integrated. However, it does have some powerful features and produces compact assembly code. A number of folks are using this one to build some fun projects like interfacing a Gameboy camera to a PC. Check the sources for the web sites.

Dontronics has yet other Basic's available. Check the sources for C compilers, both free and commercial.

Assembly

Free assemblers are easy to find. Just about every manufacturer's web site has downloadable assemblers or links to one. The Atmel assembler is a text editor and assembler in one integrated Windows environment. However, the editor is very stripped down.

There are some excellent free text editors like Programmers File Editor and the ACIDE programmers editor.

Text editors for programmers have special features needed when writing and compiling code. Some features include "language awareness," for example, if a semicolon is typed, the editor would recognize that the rest of the line is a comment and change the color or case of that text.

A necessity is the capability to run DOS batch files or DOS command line programs from the editor. Most assemblers are available in DOS versions for this purpose. With a single keystroke one can

Web Sources
Here are just a few "getting started" links ...

Atmel Corporation http://www.atmel.com/atmel/products/prod23.htm

Web Ring and Email List
AVR web ring, 81 sites http://nav.webring.yahoo.com/hub?ring=avr&list
AVR Forum — Kanda Co. http://www.avr-forum.com/
Bascom Email list http://www.grote.net/bascom/

Basic Language
BascomAVR by MCS http://www.mcselec.com/
JAVR Basic language

C Language
GNU C info http://avr.jpk.co.nz/mailman/listinfo/avr-gcc-list/
AVR-GCC FAQ by Kurt Stevens http://www.bluecollarlinux.com/
C language http://www.imagecraft.com/

Programmers
AVR and 8052 Programmer http://www.iguanalabs.com/2051prog.htm
Dontronics — SimmStik and more http://www.dontronics.com
Simmstick design contest $500.00 prize http://www.simmstick.com/

Projects and Code
AVR ethernet project http://avr.jpk.co.nz/eavr/eavr.html
AVR ethernet project http://liquorice.sourceforge.net/hardware/
Gameboy camera to parallel port
http://homepages.paradise.net.nz/~vkemp/gbcam.htm
Gameboy camera interfacing for robotics
http://members.home.net/daniel.herrington/gbcam.html
AVR analog and motor ideas http://www3.igalaxy.net/~jackt/analog.htm#pwm

AVR File Archive
http://members.tripod.com/Stelios_Cellar/AVR/AVR_File_Archieve.html

Schematic for Dongle and Adaptor
Dongle schematic http://bray.velenje.cx/avr/isp/isp.html

Link Pages
AVR embedded resources — HUGE! http://www.ipass.net/~hammill/newavr.htm
MCS Electronics links http://www.mcselec.com/links.htm

Photos, Details of the ISP in Article
http://NorthlightSystems.home.att.net/AVRisp.htm

compile, download to programmer, and return to the editor.

BASAVR Dimmer/ Motor Speed Control

The BASAVR example code listing is for a two-output light dimmer/motor control. The main loop runs fairly quick. The interrupt uses about 1/3 of the total processor time, leaving enough time for the main loop to accomplish some moderate tasks without bogging down too much. The example executes a crossfade forever.

This code demonstrates Basic's ability to use interrupts and inline assembly language. The listing is well commented, so I'll let you figure it out. (I hope you read the Nov. and Dec. 2000 issues of *Nuts and Volts*.)

With a few changes in the main loop, the example software could be used as an AC motor speed controller.

Starting Out

One easy way to get started with the Atmel AVR is with the STK200 Starter kit from Atmel. This kit is only $49.00 from Digi-Key and is available on the web, check the sources. The latest version is the STK500 for $79.00.

The STK200 board has eight LEDs, eight push-button switches, an LCD connector with contrast control pot, variable analog voltage reference, and sockets for most of the AVR family from eight-pin to 40-pin chips. It also has a DB 15 connector for serial port hook-up to a PC. It comes with an AT90S8515, 40-pin microcontroller, and a CD with the complete Atmel web site on it. It would be hard to build this board for the cost and it is very convenient. Bascom even comes with example programs for the STK200 — talk about instant gratification.

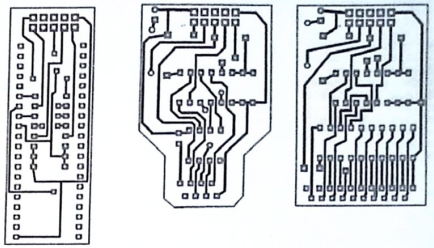
One modification I did right away was to desolder the crystal from the board. Then I carefully cut a couple of pins from a machine pin IC socket and soldered them where the crystal was; makes a great socket for easy crystal changes.

The STK200 has great web support. Kanda Company offers excellent web support for the STK kits and even sells them online. The AVR forum at the Kanda web site is a great place to start. There is also the AVR web ring, this can keep you reading for weeks. The variety of projects and source code is fantastic.

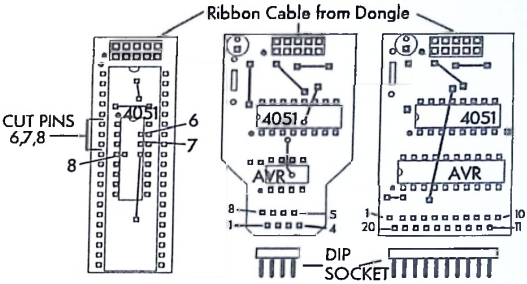
Make an ISP

The STK200 dongle will flash program the

FIGURE 2



PC BOARD LAYOUT FOR 8,20 AND 40 PIN AVR'S



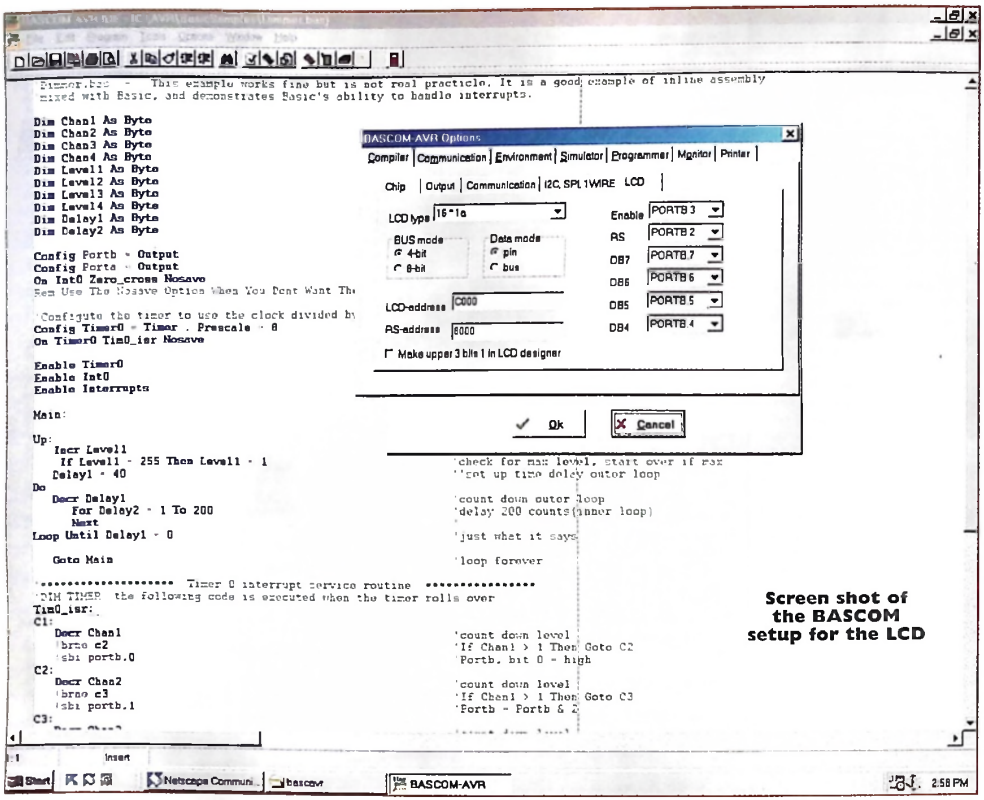
PARTS AND JUMPER PLACMENT

```
'Dimmer.bas — This would also work as a motor speed control with a properly
'set-up triac.
'This example works fine, but is only useful as a simple light dimmer or motor
'control.
'It is an example of inline assembly mixed with Basic.
'Also demonstrates Basic's ability to handle interrupts.
'The timer interrupt
'uses about 1/3 the total processor time.
'An external circuit creates a pulse every zero crossing of the AC line. This triggers
'the interrupt ISR, "Zero_cross."
'Timer 0 is used to generate the "dim levels." Timer 0 will roll over
'128 times every half cycle of the AC line. This generates 128 levels
'of brightness.
'
$regfile = "c:\bascavr\8515def.dat"

Dim Chan1  As Byte                  '"working" dimmer level
Dim Chan2  As Byte
Dim Level1 As Byte                  'commanded dimmer level
Dim Level2 As Byte
Dim Tt     As Word                  'use for time delay

'
Config Portb = Output
Config Int0 = Falling               'detect falling edge of trig pulse
On Int0 Zero_cross                  'Initialize the INT0 Interrupt
Rem Use Nosave Option when you dont want the internal registers
saved/restored
'Configure the timer to use the clock divided by 1, 8, 16 64
Config Timer0 = Timer , Prescale = 1 'Set up Timer0
On Timer0 Tim0_isr                  'Define the ISR handler
Enable Timer0                       'Start Timer
Enable Int0                         'Enable External interrupts
Enable Interrupts                   'Global interrupt enable
Portb = 0                           'turn off all triacs
'********** Main loop does crossfade forever **********
Main:                               main program loop
Up:
  Level2 = 129                     'make sure level correct
  For Level1 = 1 To 128            'increase level 1 notch each loop
    Decr Level2                    'decrease other channel
    Waitms 4                       'wait here 4 milliseconds
    'for tt = 1 to 190
    'next
  Next
Down:
  Level1 = 129                     'make sure level correct
  For Level2 = 1 To 128            'increase level 1 notch each loop
    Decr Level1                    'decrease other channel
    Waitms 4                       'wait here 4 milliseconds
  Next
    Goto Main                      'loop forever
'********** Timer 0 interrupt service routine **********
'DIM TIMER  the following code is executed when the timer rolls over
Tim0_isr:
    !cbi PORTB,5                   'scope trig
C1:
  Decr Chan1                       'count down level
  If Chan1 > 1 Then Goto C2
    Reset Portb.0                  'If Chan1 > 1 Then Goto C2'Portb. bit 0 = high
C2:
  Decr Chan2                       'count down level, set pin when equal
  !brne Dim_done                   'If Chan1 > 1 Then Goto dimdone
  !cbi portb,2                     'Portb = Portb & 2
Dim_done:
    Tcnt0 = $068  '$062 = 128 levels     'prescale timer
    !sbi PORTB,5                   'scope trig
  Return                           'return from interrupt
'********** External interrupt - Zero Cross **********
'This code is executed when the external zero cross circuit triggers an interrupt'
Zero_cross:
    Chan1 = Level1                 'reset current dim level
    Chan2 = Level2
    Portb = 255                    'turn off all triacs
  Return
'*****************************************

End
```



Screen shot of the BASCOM setup for the LCD

AVR through the PC printer port, which is very convenient. The catch is the target board has to accommodate the programming header from the dongle and the requirements of the programming pins during programming. This is true for the STK200, as well. The simplest way to do this is with a couple of resistors and a programming header.

However, this doesn't work in all cases. The manual gives circuit examples of a universal method. This is accomplished with the use of a 74HC4053 multiplexer chip to isolate the micro during programming. The multiplexer chip connects the micro's programming pins to the printer port dongle during programming, then switches to the external circuit during normal operation (see Figure 1).

Rather than include the 4053 and header on each target board, I decided to put the programming header, microprocessor, and 74HC4053 multiplexer chip on a small board of their own (Photo 1). This adapter board plugs into the microcontroller's socket on the target board. With this set-up, it is possible to do in-circuit programming on any target board. When the code is finalized, just pull the processor chip off the adapter and plug into the target board.

The abundance of low-cost tools makes the AVR a good choice for home project builders.

Making the adapter should be done on a printed circuit board. I used presensitized PC boards. The negatives were printed on clear film with a laser printer. The single-sided boards for the eight- and 20-pin AVRs are easy to build.

After installing the sockets and jumpers, the DIP header needs to be mounted to the bottom of the board. The DIP header or machine pin socket is mounted perpendicular to the circuit board. I attached the sockets to the board with tinned, solid hook-up wire. A little epoxy or silicone will lock it all together. It sounds more difficult than it is.

The 40-pin adapter requires a 40-pin wire-wrap socket and a 40-pin DIP header to create the double-decker ISP adapter. The single-sided board is the mounting platform for the 4053, programming header, and jumpers. The wire-wrap socket pins pass through the PC board holes, and then are soldered from below. The short ends of the wire-wrap pins that poke through the board will be used to solder the 40-pin DIP header to the adapter. Pin 9 of the wire-wrap socket should be cut just below the PC board. It should not be soldered to the header pin.

Pins 6, 7, and 8 of the wire-wrap socket have to be cut above the circuit board. Jumpers are soldered from the cut pins to the PC board as noted in the parts placment diagram in Figure 2.

Always use two sockets on the bottom of the adapter to protect the adapter pins from damage.

Note that the target circuit must supply a crystal or clock signal to the adapter during programming. Power is supplied by the target circuit. The reset pin is controlled by the adapter.

Using the ISP adapter/dongle with BascomAVR is a breeze. Just select the STK200 option under "Programmers." Write your code, then click the compile button. Once compiled, the software will "auto-program" the micro. Any code changes will be immediately executed. This is great if you like "crash and burn" software writing. The adapter works well with the AVR-ISP software also if you use other software.

Other Options

I must mention the ever-popular SIMM Stik's sold by Dontronics and others on the web. Dontronic's web site is crammed full of development boards and programmers for the AVR and PIC micros. It is also a good source for several Basic and C compilers. They have online ordering.

If you want to make your own dongle, this is not so tough. There are several sites that have schematics for dongles.

If you want to try your hand at microcontroller programming, this is a powerful and easy micro to start with. The abundance of low-cost tools makes the AVR a good choice for home project builders. **NV**

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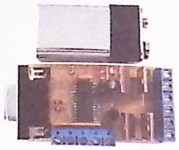

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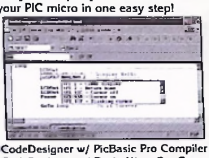

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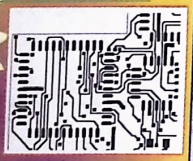

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by Dennis Shepard

Build Your Own Model Train Voice Recognition Control System

ALL ABOARD ... brings back memories of an old-time conductor looking at his pocket watch to let the engineer know it was time to start the train. Even if you've never been on a *real* train, images from classic TV movies should bring about memories of a time gone by when both people and freight traveled across the country by railway. Because it's part of our heritage, hobbyists have found model railroading to be an interesting way to spend their time.

Over the years, these model train enthusiasts have sought to add all the realism they could to their scaled-down layouts to duplicate conditions in the real world. They have even been able to duplicate the slow starting and stopping characteristics of a real train using electronic circuitry to mimic these functions. This has developed to the point of having separate decoders inside the locomotives which can control several trains on the same track by sending computerized signals over the tracks to each train.

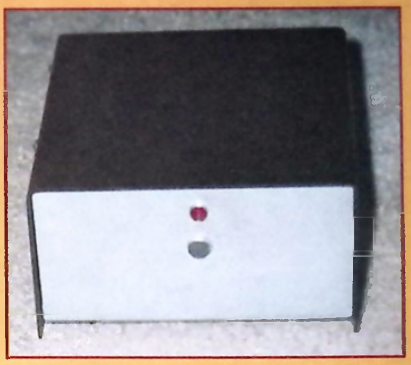
Until recently, however, the only thing missing was the ability to control these functions by voice command.

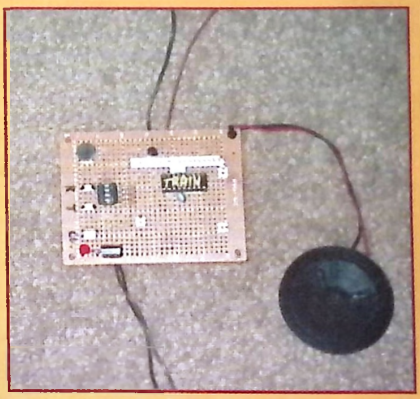
Using a VD364 module from Sensory – for whom I am a consultant/developer/distributor – the system gives you complete control using three separate voices to control faster, slower, complete stop, momentum start, and momentum stop functions as Commands 1-5. Not only that, but it's trained to respond to your voice alone ... and in any language to boot! And since you've already got a power supply, you can build this for around $100.00. If this sounds interesting ... then let's get started.

Sensory to the rescue

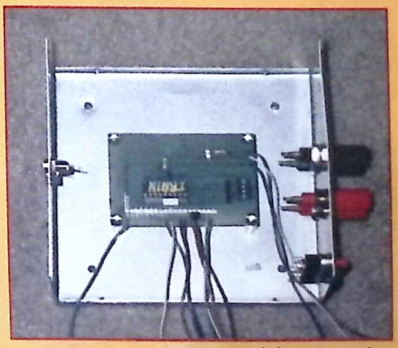
A hi-tech company located in the heart of Silicon Valley in California, Sensory recently came out with the VoiceDirect 364 module. They had earlier versions, but it always required some interaction to get it to recognize words or phrases. They finally leaped that hurdle and came up with a module that would respond to an entry or 'gateway' word or phrase. This is followed by a command word or phrase, which can be several seconds long. In other words, it is strictly voice-controlled! By slightly changing the wiring of the unit, you can either use one gateway word with 15 commands or three gateway words with five commands apiece.

Since I couldn't imagine 15 different things you would want to do with a model train controller, I settled for five commonly-used commands which allow three separate voices to use those functions. The commands are completely interactive and can be followed in any order to achieve that function. In other words, you can go from complete stop, to faster three-four times, momentum start to full speed, to slower several times, to complete stop or momentum stop. It's easy to

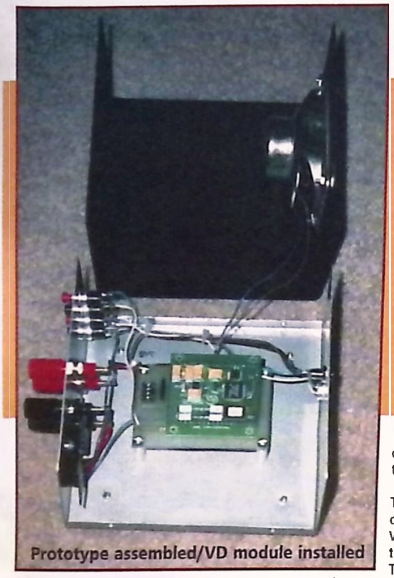




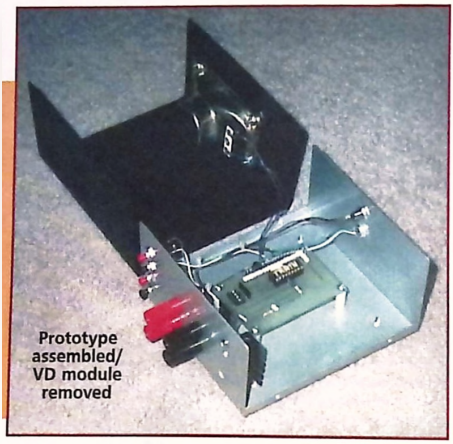
Prototype on Perfboard/VD module removed



Prototype on PCB/VD module removed



Prototype assembled/VD module installed



Prototype assembled/ VD module removed

see how exciting and how much fun this could be!

Details of the interface

One of the drawbacks about the voice recognition module is that the outputs are temporary, in that they only stay on for one second. The first eight outputs come on by themselves, but outputs 9-15 are a combination of output 8 plus outputs 1-7. Out of the box, you could wire the outputs through switching transistors and operate switchyards or the like, but you can only use the first eight outputs without some type of decoding. Although this limits the possibilities somewhat, both of these situations can be effectively dealt with. Now here's where it gets a bit technical.

Using a microcontroller chip (Microchip Technology PIC 16C54) to read the eight outputs, the PIC generates a PWM (Pulse Width Modulated) output to the HEXFET transistor (International Rectifier IRLZ 14). These transistors conduct completely at ~ 5 VDC on the gate terminal with an 'on' resistance of 0.2 ohms. The output of the power transistor is wired in series with the power supply and the train, and provides a very sophisticated control system with a minimum of parts. Using your train power supply, you can set your maximum speed and change it anytime you want.

Construction details

The prototype was built on 2-3/4" x 3-3/4" grid-style PC board from RadioShack (RS #276-158). They also sell 30 gauge insulated wire which I soldered between the components for hook-up. Although a printed circuit board (PCB) can be designed for the unit, it isn't necessary because of the simple circuitry. However, we've designed a PCB and built one of those for the finished product, as well.

To save space, the voice recognition module is piggybacked on the perfboard. The module comes with standard 0.1" headers to accept 0.1" posts which are soldered to the PC board. The microphone, LED, speaker, switches, and transistor are mounted on the enclosure. Since the transistor will be generating some heat, it is most important it be mounted with heatsinks to a metal enclosure to dissipate that heat.

However, you can use the transistor's operating characteristics to your advantage. This means that if you are traveling along at a constant speed and you hit an increased grade (you're going uphill), the increased current will cause the transistor's resistance to increase slightly and deliver less torque to the engine. This easily simulates the way a real train reacts on an increased grade.

Completed unit/ rear view

And, after all, we're after as much realism as we can get!

Setting it all up

Now we get to the fun part. As I mentioned earlier, the VoiceDirect module is the heart of the system. Besides the eight outputs mentioned previously, the module has a microphone input, a speaker output, some programming switches, and an LED indicator. The system uses three separate push-button switches to perform the programming, set-up, and erasing of the speech template. Here's how it goes in detail:

On power-up, the VoiceDirect module does internal diagnostics and will beep the speaker once when this is complete. The LED will be off if the unit hasn't been programmed yet or has been erased. The unit is erased by holding the RECOGNIZE and TRAIN buttons together for one second. The module will respond with "memory erased."

Now we're ready for the actual training session.

Since the unit has been wired for multi-word continuous listening mode, pressing the CL TRAIN button will prompt you to "say word 1." This is the gateway word for person 1 and can be spoken as "person 1, Bob's train, voice control" or what have you. The unit will ask you to "repeat" each word or phrase. If the word or phrase matches, the unit will respond with "accepted."

Now you press the TRAIN button to program the five commands for each track. After each command is accepted, you press the TRAIN button again for the next word. You have to program all five words before proceeding to the next track. Then you simply repeat the process all over again until all three voices are programmed. The unit will talk you through it with prompts such as "please talk louder" or "similar to a prior word." Just follow the friendly instructions and you'll be set up in no time!

Once the words have all been trained, it's time to put the unit into operation. Press the REC-

Table 1

SW4	SW3	SW2	SW1	Speed Change Step
0	0	0	1	1
0	0	1	0	2
0	0	1	1	3
0	1	0	0	4
0	1	0	1	5
0	1	1	0	6
0	1	1	1	7
1	0	0	0	8
1	0	0	1	9
1	0	1	0	10
1	0	1	1	11
1	1	0	0	12
1	1	0	1	13
1	1	1	0	14
1	1	1	1	15

Sensory has a website @ http://www.sensoryinc.com. You'll find complete instructions and details of the module along with other interesting information. Be sure and tell 'em we sent ya.' A VoiceDirect 364 module is available for $50.00 plus $5.00 S & H. The preprogrammed PIC, ceramic resonator, voltage regulator, one each. IRLZ 14 HEXFET transistors are available for $20.00. If both are ordered together, the shipping and handling charge is waived. California residents please add state sales tax. We accept money orders (preferred), cash, or Western Union if you're in a hurry! Please make payment payable to:

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Voice Recognition Train Control System Parts List

C1 0.1 uF, 50 WVDC monolithic capacitor RadioShack #272-109 or equal
*CR1 4.00 MHz Ceramic Resonator Digi-Key #PX400-ND or equal
*IC1 Microchip Technology PIC 16C54-XT/P microcontroller Digi-Key PIC #16C54-XT/P-ND (requires programming)
JP-x See below
LED1 T1-3/4 Green LED RadioShack #276-022 or equal
LED2 T1-3/4 Green LED RadioShack #276-022 or equal
MIC1 Omnidirectional Electret microphone element RadioShack #270-092 or equal
PS1 Power supply 9-24 VDC 100 mA output RadioShack #273-1767 or equal
R1-R2 330 ohm, 1/4W, 5% carbon resistor RadioShack #271-1315 or equal
R3 47K ohm, 1/4W, 5% carbon resistor RadioShack #271-1342 or equal
R4-R7 10K ohm, 1/4W, 5% carbon resistor RadioShack #271-1335 or equal
S1-S4 SPST momentary contact push-button switch RadioShack #275-1547 or equal
*T1 International Rectifier HEXFET transistor Digi-Key #IRLZ14-ND or equal
*VR1 78L05 5 VDC 100 mA voltage regulator Digi-Key #78L05ACZ-ND or equal
*Voice Recognition module VD364 Voice Recognition module Sensory #VD364

Misc. Small enclosure w/8- ohm speaker, 0.1" male headers, hook-up wire, etc.

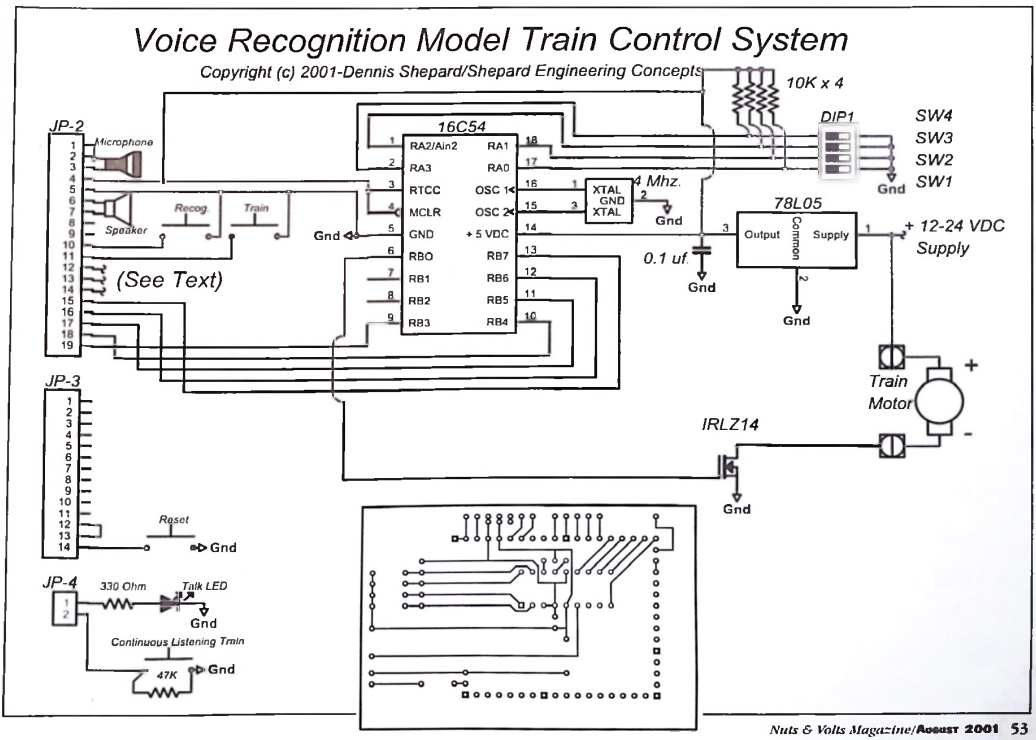
*The following items are available directly from Shepard Engineering Concepts. A kit of programmed IC1, CR1, T1, and VR1 are available for $25.00 ppd. A kit including these items and the voice recognition module are available for $75.00 ppd. These prices are for the continental US only. Please make payment to: Dennis Shepard.

OGNIZE button and the LED will come on. The system is now in continuous listening mode. As soon as it recognizes one of the three gateway words, the LED will extinguish for one second and the speaker will tell which gateway # word was recognized. If the system recognizes the command after this, the unit will send the appropriate command to the track.

Since momentum start and stop are time-activated controls, the unit will not respond to other commands during this time, even though it's possible for the VoiceDirect module to recognize it. This is because the time delay is many times longer than the voice recognition time. Please keep this in mind so you have a clear understanding of how the system operates.

Speaking of the momentum commands, the four-pole DIP switch is used to determine the percentage of step change per second. It's a straight binary code from 1-15, depending on the individual settings, so you can change from 1-15% speed change per second. This works for both momentum start and stop commands. And don't forget ... if you don't set ANY switches, these commands won't work. Check out Table 1 for the breakdown.

I certainly hope that you get excited about the possibilities here. **NV**



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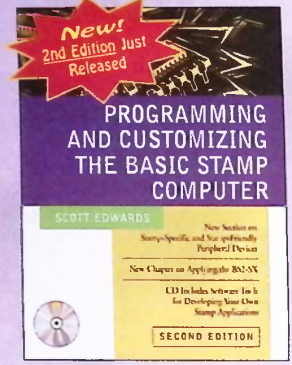

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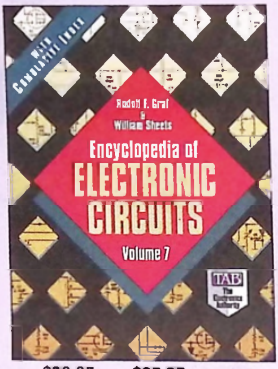

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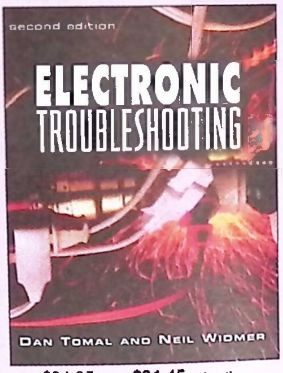

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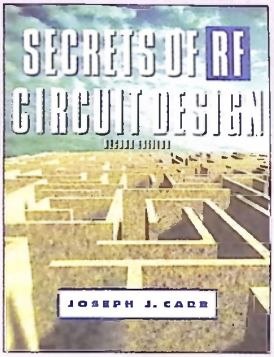

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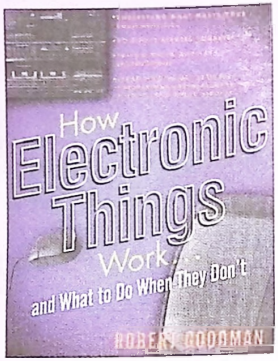

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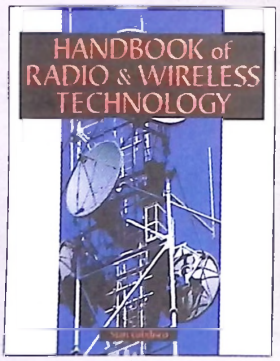

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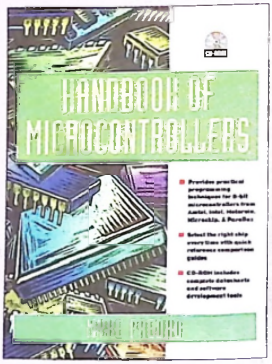

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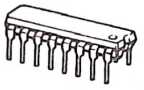

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Laser Insight

NEW COLUMN!!

by Stanley York

Back to basics

This month, we're going back to basics and look at general optical principles, mirror coatings, and how lenses work, but we'll finish up looking at how to improve the quality of a laser beam. First, though, the basics.

We all know how mirrors work. The angle of reflection equals the angle of incidence for a flat mirror. Things get a little more complicated when we start to deal with curved mirrors, though, although the same general principles apply. That's something we learned in junior high school. But now we are dealing with lasers, and mirrors take on a new meaning, and in some cases, a totally new appearance.

If you have a HeNe laser you experiment with, take a look (with the power off, of course!) at the end mirrors. You'll notice that they are not red or silver, but rather a yellowish or greenish color. We'll get to why that is in a minute.

I remember the first time I saw an Nd:YAG (Neodymium-doped Yttrium Aluminum Garnet) mirror, I was quite surprised to find that the mirror was almost totally transparent, yet it was a 100% reflecting mirror at the Nd:YAG wavelength (1,064nM). Even more surprising, was when I began working on CO_2 lasers, and found four distinctly different types of material for these mirrors, two of which were completely black! But again, we'll answer some of these anomalies in a minute.

Mirror coatings

The mirrors we see in everyday life usually have a coating of silver or aluminum and are covered with a thick coating of paint for protection. These mirrors reflect all the visible wavelengths of light, and we are able to see reflected images of everything around us in them. But these types of mirrors would not work too well in a laser application, and this is why most laser mirrors do not look at all like the mirrors we are used to seeing.

Laser mirrors are designed specifically for the type of laser they will be used in. Usually, mirrors made for laser applications are thick and use a variety of glasses, depending on whether the glass is used for reflecting, transmitting, or some combination of these. So-called multilayer dielectric coatings are applied to laser mirrors. These coatings are normally some kind of metallic coating, extremely thin, and fragile.

The coating type and thickness determines the operating wavelength of the mirror. The coatings are applied to the mirrors using a special process in high-vacuum chambers. Metal is evaporated, and a high-voltage field propels atoms of metal toward the heated mirror, building up the coating slowly and uniformly, atomic layer by atomic layer. This special process is one of the reasons that laser mirror prices are so high. Not just mirrors, but all optical components used in a laser are precision-made, expensive, and must be handled with great care.

The coating thickness and material type determines the wavelength of light that the mirror will preferentially reflect. Figure 3-1 illustrates how an AR (for Anti-Reflection) coating works. This type of coating is designed to permit maximum transmission (i.e., minimum reflection) of light through an optic, whether it is a mirror, a lens, a prism, or some other optical device. When the incident beam A strikes the surface of the AR layer, reflected light waves are returned along path B.

Some of the light passes through the layer to the surface of the optic, and strikes the AR layer/optic surface boundary. Here, the coating thickness is chosen to be about a 1/4 of a wavelength of incident light ($\lambda/4$) to reflect the beam C back to the surface of the AR layer that is 1/2 wavelength out of phase with the beam reflected from the surface of the AR layer.

Because the two reflections are in opposite phase with relation to each other, they effectively cancel each other out and result in almost zero reflection from the optical surface. This is the case for an AR coating.

To get a high reflectivity coating, all we have to do is make sure that the reflected waves from the AR layer/optic surface boundary are in phase with those reflections from the top surface of the AR layer, thus giving maximum reflectivity and minimum transmission at the particular wavelength we require.

In this manner, we can put further coatings on the glass substrate (term applied to any uncoated optical element) to provide any degree of reflection/transmission ratio that is required. The beamsplitter is a good example of this.

Many industrial applications use a laser that has a multiple beam output. In some cases, the beams are carried by fiberoptic to the point of use. In all cases though, the laser beam is split using mirrors that reflect part of the incident beam and allow the remaining beam to pass through, possibly going into another beamsplitter.

In this way, with careful choice of coatings, multiple beams can be obtained from the same laser. Of course, since energy is extracted from the laser beam at every beamsplitter, there is a gradual fall in laser intensity as the beam progresses through the series. It is for this reason that beamsplitter coatings have to be carefully chosen to give correct results.

As an example, I once had to split a 1kW CO_2 laser beam into four identical outputs for a production welding application. The first

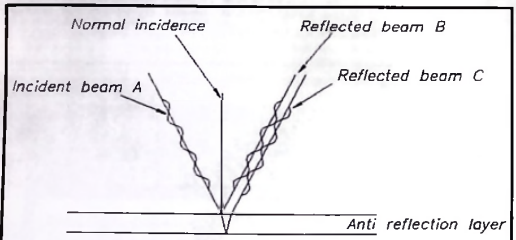

Figure 3-1 — Anti-reflection coating principle

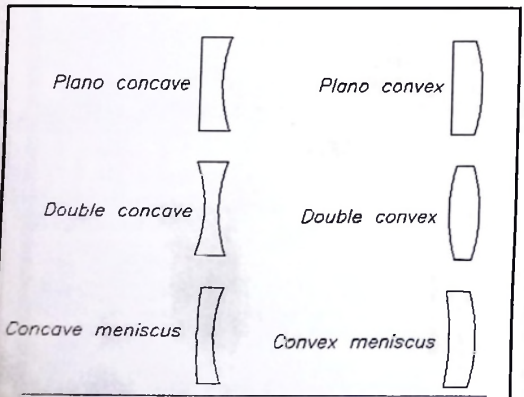

Figure 3-2 — Common lens shapes

beamsplitter was a 25% reflecting, 75% transmitting, to give 250W. The second one was a 33% reflecting, 67% transmitting (after the first splitter, there was only 750W left), the third was a 50% reflecting, 50% transmitting (to split the remaining 500W), and the fourth was a 100% reflecting. All at 45° angle of incidence.

Okay, getting back to the beginning of this column. Remember I said that the 100% reflector for Nd:YAG was almost totally transparent? You could probably understand why now. It's all to do with wavelength.

Nd:YAG lasers emit a beam at 1,064nM. This puts it into the near infrared (the visible spectrum ends at about 700nM or so). So, a coating for this wavelength may not stop any visible light at all! That's why it appears almost transparent. There is a very slight coloration to an Nd:YAG mirror, and that coloration depends more on the material used to coat it, rather than the thickness of the coating.

I also said back then that the CO_2 laser uses at least four types of material for mirrors.

The first one I became familiar with was salt. Yes, salt. You may think I'm going nuts, right? Well, let me clarify things a bit. It wasn't salt that you find on your dinner table (although, given the right conditions ...). This salt was Potassium Chloride, usually called KCL. The problem with KCL is it absorbs moisture right out of the air, and it poses serious problems when it starts to absorb moisture.

The second and third materials I came across were Germanium – the same stuff they used to make transistors out of – and Gallium Arsenide. These two were totally opaque to visible light, yet the CO_2 wavelength could easily pass through them. CO_2 wavelength is 10,600nM (10 times the wavelength of Nd:YAG). This wavelength puts this laser into the far infrared.

The fourth material is one you may have already heard of, Zinc Selenide. It's a clear yellowish material that allows visible light to pass through, as well as the infrared. This material is more expensive than any of the others, but in terms of performance and ease of setting up the laser for experiments, it is well worth the added cost.

Lenses

The subject of lenses is a fairly long and involved one, so we're not going into it too deeply here. There are many good books out there if you wish to go into greater depth, but we will try to keep things simple in this article. What we'll do is look at lenses in general, see how they work in combination, and finally see how they can be used to correct divergence in a laser beam. We shall discuss only a few principles here, as they relate to laser use.

Figure 3-2 shows us some fairly common lens shapes. Those on the left are diverging lenses; those on the right are converging lenses. The two types shown are known as simple lenses (there is only one element to each). Other lenses are made up by cementing together different lenses – sometimes made of different glass – to achieve special characteristics. These types will not be dealt with this time though; otherwise, we would take up the whole magazine! For all the equations that follow in this issue and future articles, we shall assume that the light rays entering the lens or lens combination are close to, and parallel to the optical axis. See Figure 3-3.

Perhaps a word is in order here about laser damage threshold in optical devices. Although most optical glasses are very clear, there is always a danger when using focusing optics, that the energy density may reach unsafe levels (for the optics, that is). Most optical products made for laser use have an upper laser damage threshold of approximately 500MW/cm^2. That is to say, that under normal operating conditions, the optic may suffer irreparable damage if the power density reaches 500MW/cm^2 or above. This is a very high number though, and it is very unlikely that you will ever see power densities as high as this, unless you are in the laser industry.

A 200 watt laser with a beam diameter of 6.35mm (1/4") has a power density (assuming a perfectly uniform spatial profile) of 631W/cm^2. Pretty tame. But if that beam is focused down to a spot size of 1mm, the power density zooms up to 6369W/cm^2. Going one step further, if the beam is focused down to 0.5mm diameter, the power density leaps up to over 25 kilowatts/cm^2. A little more serious, and enough power density to do real damage. This concentration of laser power is enough to melt stainless steel. I know, because my daily work involves the laser welding of stainless steel, and I use a 200W laser to accomplish the task.

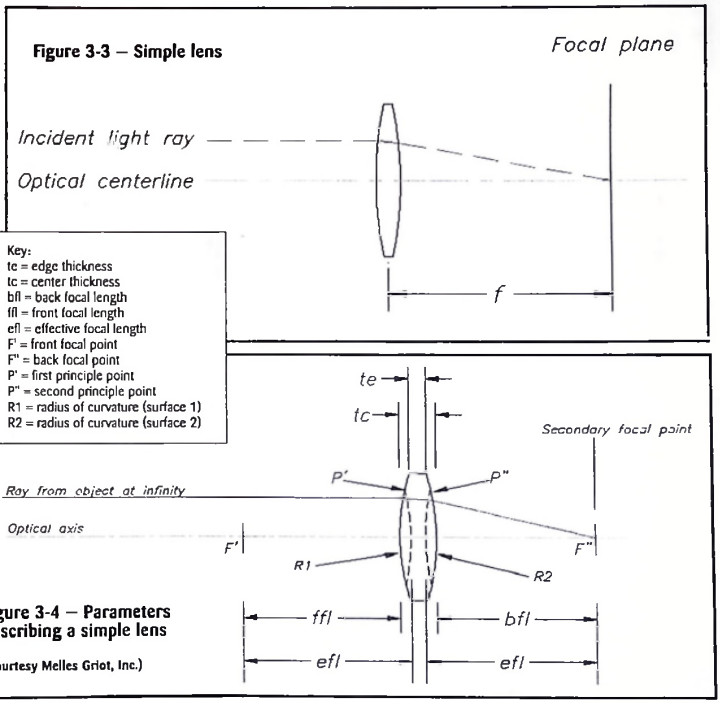

Figure 3-3 – Simple lens

Figure 3-4 – Parameters describing a simple lens

(Courtesy Melles Griot, Inc.)

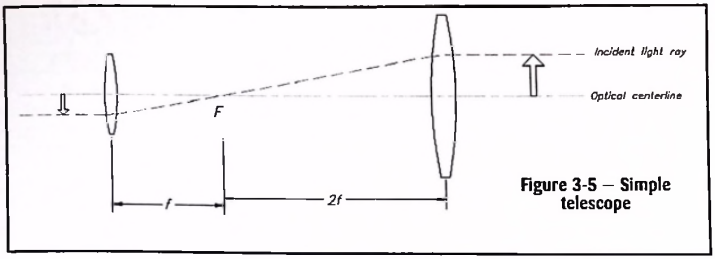

Figure 3-5 – Simple telescope

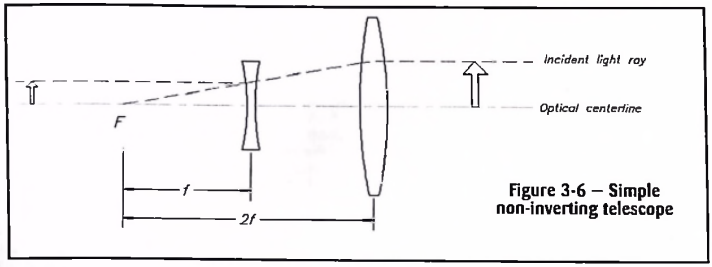

Figure 3-6 – Simple non-inverting telescope

how enormously high powers are generated using a laser. You sometimes hear how research labs around the country have generated laser powers reaching thousands of megawatts; I'll tell you later how they do that. It won't be easy for the amateur to achieve these power levels, but I will tell you a cheap and easy method of generating a few hundred kilowatts!

Returning to Figure 3-3, we see light rays coming in from the left of the page and entering the double convex lens at some distance from the optical center of the lens. Upon reaching the interface, the light ray bends or refracts toward the normal, and continues on to the second interface, where it again refracts, and continues on, following a different path than when it entered the lens. Where the emerging light beam crosses the optical centerline is known as the focal point of the lens, and is usually designated *f* in most optical texts.

The distance *f* is called the focal length of the lens. (Here it is approximated to the center of the lens. In fact, it is a little more complex than this, but for the sake of keeping things simple, we'll use the thin lens equations where we need to, and assume that the center of the lens is the reference point for measuring the focal length.)

A quick and dirty method of measuring the focal length of a plano convex or double convex lens is to find a location that has some bright, easily-defined objects in the distance.

As an example, stand against a wall facing a window on the other side of the room. Tape a piece of white paper to the wall you're standing by. Hold the lens up so that light from the window is projected through the lens and onto the paper. Vary the distance of the lens from the paper until a sharp focused image of the window is formed. If there are objects outside the window – for instance, a tree – then try to get this into focus on the paper. Since this is more distant than the window itself, the light rays coming from the tree will be more nearly parallel than those coming from the window alone. If this can be done while holding a scale against the lens to measure the distance from the wall, then the focal length of the lens *f*, can be read off the scale.

There are a number of terms used in describing the various characteristics that define a lens, and some of the more important ones are given here in Figure 3-4.

When specifying lenses, the manufacturer may require some of the listed parameters if the lens is a new design. For most applications, though, lens designs have been standardized by many of the major manufacturers and produced in large numbers to reduce costs. Very often we see lenses used in combination. In a telescope, for example.

Let's examine briefly how a simple telescope is made. In Figure 3-5, parallel light rays enter the lens and are brought to a focus at a distance *ef* from the lens. If a second lens of double the focal length is introduced at a distance *2ef* from the focal point, the converging rays cross over and become diverging on the right side of the focal point. If these rays entering the second lens are made parallel again, we have the essential features required for a telescope.

In this drawing, we have an eyepiece lens, whose focal length is *f*. The objective lens is slightly larger in diameter, and has a focal length of exactly twice that of the eyepiece lens, or *2f*. You'll see in the drawing that the two lenses are positioned such that the two focal points are coincident at F, the common focal point.

This type of telescope – using two convex lenses – is known as a refracting telescope, since it relies on the refracting properties of lenses to achieve the desired results. The telescope as shown, inverts the image seen and is therefore not much use for looking at distant terrestrial objects. However, for looking at the moon and planets, it doesn't really matter that the image is inverted, and so simple astronomical telescopes are usually constructed this way. The magnification of such a telescope is easy to determine, once we know the focal lengths of the lenses used. Magnification power = focal length of objective lens/focal length of eyepiece lens.

In our example, the objective lens is twice the focal length of

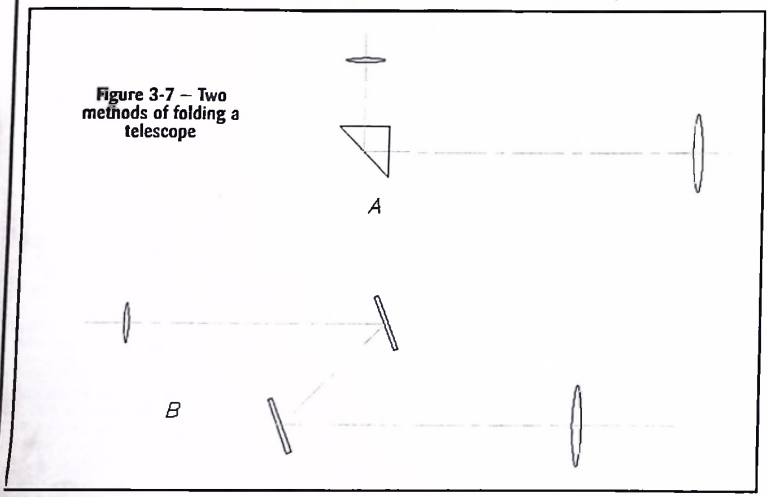

Figure 3-7 – Two methods of folding a telescope

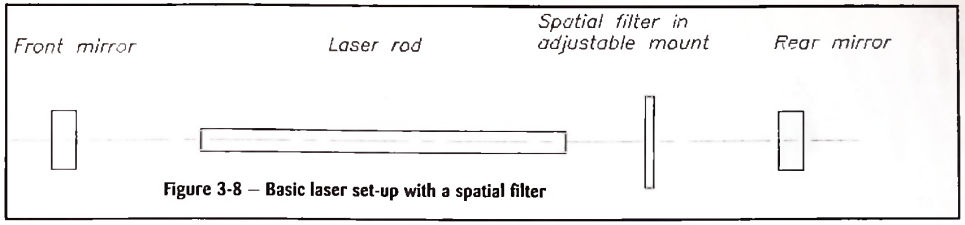

Figure 3-8 – Basic laser set-up with a spatial filter

the eyepiece lens, and so the magnification is two. To make this type of telescope useful for land observations, we need to invert the image again. This can be done in two ways: either by interposing another lens in the eyepiece, which is the usual way. Or, replace the eyepiece lens with a concave lens, as in Figure 3-6. In this arrangement, the focal points of the double convex and the plano-concave lenses should coincide. Again, the magnification factor of the telescope is focal length of objective/focal length of the eyepiece.

In the previous example, the length of the telescope is the sum of the focal lengths of the two lenses. It's the same in Figure 3-6, but one of the lenses (the eyepiece) is a negative lens, and the addition of the two results in a shorter telescope.

Where the ratio of the objective and eyepiece lenses is large, the magnification is high, and the telescope can become ungainly and hard to control. In these cases, we can use prisms or mirrors to bend the telescope in any number of ways to make it more manageable.

Figure 3-7A shows a prism being used to reduce the overall length of an astronomical telescope. The problem of doing this is that the image becomes reversed left-to-right as well as top-to-bottom. Figure 3-7B shows another method of shortening the length of a telescope without introducing an image reversal. Two flat mirrors are used to redirect the light rays from the objective lens toward the eyepiece, thereby causing two reversals of the image. This is the same principle as is used to make binoculars, where prisms are normally used instead of flat mirrors.

Better laser beams

But this is a laser column, so we can't leave without talking at least a little about lasers.

In last month's column, we saw how a laser beam can have several operating spatial modes, and we also saw how those spatial modes appear when exposed to film. We're going to see now how some of these extraneous modes can be filtered out, and how the beam divergence can be improved.

With any laser, if control can be obtained to limit the maximum number of spatial modes that are allowed to operate, the end result will be a lower-order mode beam than would otherwise be made. That much stands to reason. But how to get control, that is the question.

The usual way to get the high quality beams used for holography and interferometry is to use a spatial filter somewhere within the resonator (the space between the end mirrors, see Figure 3-8). A spatial filter limits the active volume of the gain medium (the laser gas or rod available for lasing) and prevents the higher-order modes from becoming significant in the lasing process.

The way it works is this. A pinhole is drilled into a mountable block (usually metal, but ceramic is sometimes used). The block is mounted in an X-Y stage and placed on the optical rail between the laser head and one of the end mirrors. When the laser is started, the position of the pinhole is adjusted until maximum power output is obtained.

If a check is then made on the beam profile as before, it will be found that not only is the spatial power distribution better (i.e., closer to a Gaussian beam) than before, but also the beam divergence has improved to make the beam more nearly parallel. Of course, this all happens at a cost.

The price to pay for the improved beam quality is less power output from the laser, and a smaller beam cross-section. But this is not always a drawback. The tighter beam divergence, coupled with improved spatial profile, allows the beam to be concentrated into a tighter focus, which means a higher power density at the focal point. The point here, though, is to get the spatial filter inside the resonator. It is no good trying to control the spatial profile from outside the resonator, it won't work. All that will accomplish is to reduce the laser power with no improvement in mode structure or divergence.

Adding a spatial filter as indicated above will improve the mode structure and beam divergence. But beam divergence can also be improved without using a spatial filter. If we run a laser beam through a telescope in reverse, the divergence figures will improve in the same ratio as the telescope magnification. That is to say, if we have a 2:1 magnification telescope, and shoot the laser through the eyepiece lens and out through the objective lens, we will find that the beam divergence has dropped by a factor of 2.

When used in this manner, the telescope is usually called a beam expander, because the beam grows in cross sections as it travels through the telescope lens system. The beam emerging, though, will diverge at a lower rate than when it entered the beam expander, but losing no power in the process.

The point in getting improved beam quality is well justified when the laser is used for holography, which we'll cover in more depth in a later column. The laser beam quality is very important to the clarity of the finished hologram, and any extraneous spatial and longitudinal modes can ruin an otherwise perfect set-up. Interferometry is another branch of science that uses lasers and, in some instances, temperature-tuned etalons (a special kind of optical filter) are used to limit the number of longitudinal modes present in the beam.

Stay tuned to this column. Next month, we're going to describe a construction project that we will build over the next couple of issues. It will be a laser light show, and will have some features that have not been published in other magazines, and optional add-ons you can incorporate as your budget and junk box will allow. **NV**

OP-AMP COOKBOOK

by Ray Marston

Part 2 • Op-Amp Basics: Amplifiers and Active Filters

Ray Marston looks at practical op-amp amplifier and active filter circuits in this second episode of this four-part survey of op-amp principles and applications.

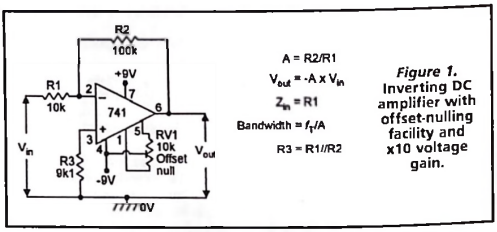

Figure 1. Inverting DC amplifier with offset-nulling facility and x10 voltage gain.

Last month's opening episode of this four-part 'op-amp' series described the basic operating principles of conventional voltage-differencing op-amps (typified by the 741 type) and showed some basic circuit configurations in which they can be used. This installment looks at practical ways of using such op-amps in linear amplifier and active filter applications.

When reading this episode, note that all practical circuits are shown designed around a standard 741-type op-amp and operated from dual 9V supplies, but that these circuits will usually work (without modification) with most voltage-differencing op-amps, and from any DC supply within that op-amp's operating range (allowing for possible differences in the op-amp's offset biasing networks).

INVERTING AMPLIFIER CIRCUITS

Figure 1 shows the practical circuit of an inverting DC amplifier with an overall voltage gain (A) of x10 (= 20dB), and with an offset nulling facility that enables the output to be set to precisely zero with zero applied input. The voltage gain and input impedance are determined by the R1 and R2 values, and can be altered to suit individual needs. The gain can be made variable — if required — by using a series combination of a fixed and a variable resistor in place of R2. For optimum biasing stability, R3 should have a value equal to the parallel values of R1 and R2.

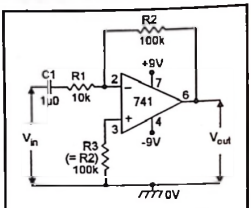

Figure 2. Inverting AC amplifier with x10 gain.

Note that the *Figure 1* circuit will continue to function if the RV1 offset-nulling network is removed, but its output may offset by an amount equal to the op-amp's input offset voltage (typically 1mV in a 741) multiplied by the closed-loop voltage gain (A) of the circuit, e.g., if the circuit has a gain of x100, the output may be offset by 100mV with zero input applied.

Also note that the circuit's bandwidth equals the f_T value (typically 1MHz in a 741) divided by the 'A' value, e.g., the *Figure 1* circuit gives a bandwidth of 100kHz with a gain of x10, or 10kHz with a gain of x100.

The *Figure 1* circuit can be adapted for use as an AC amplifier by simply wiring a blocking capacitor in series with the input terminal, as shown in *Figure 2*. Note in this case that no offset nulling facility is needed, and that (for optimum biasing) R3 is given a value equal to R2.

NON-INVERTING AMPLIFIER CIRCUITS

An op-amp can be used as a

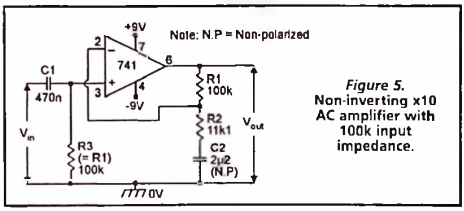

Figure 5. Non-inverting x10 AC amplifier with 100k input impedance.

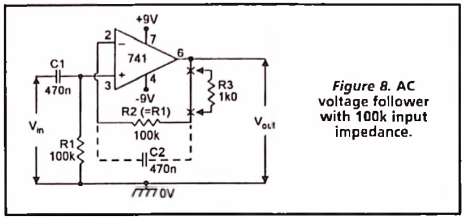

Figure 8. AC voltage follower with 100k input impedance.

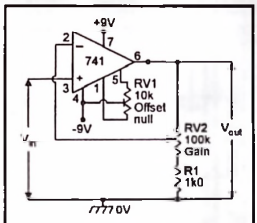

Figure 4. Non-inverting variable gain (x1 to x101) DC amplifier.

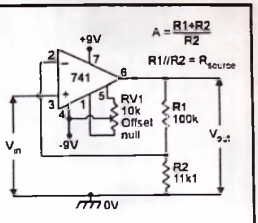

Figure 3. Non-inverting DC amplifier with offset-nulling facility and x10 gain.

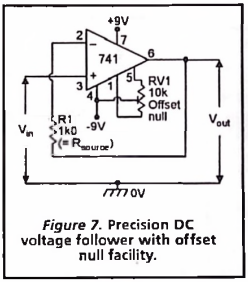

Figure 7. Precision DC voltage follower with offset null facility.

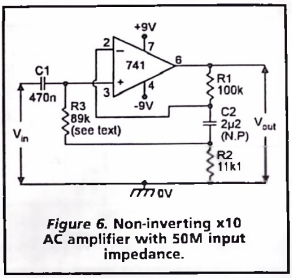

Figure 6. Non-inverting x10 AC amplifier with 50M input impedance.

non-inverting DC amplifier with offset compensation by using the connections shown in *Figure 3*, which shows an x10 amplifier. The voltage gain is determined by the ratios of R1 and R2, as indicated. If R1 is given a value of zero, the gain falls to unity; alternatively, if R2 is given a value of zero, the gain equals the open-loop gain of the op-amp. The gain can thus be made variable by replacing R1 with a pot and connecting its slider to the inverting terminal of the op-amp, as shown in the circuit in *Figure 4*, in which the gain can be varied over the range x1 to x101 via RV2.

Note that – for correct operation – the input (non-inverting) terminal of each of these circuits must be provided with a DC path to the common or zero-volts rail; this path is provided by the DC input signal. In *Figure 3*, the parallel values of R1 and R2 should ideally (for optimum biasing) have a value equal to the source resistance of the input signal.

A major feature of the non-inverting op-amp circuit is that it gives a very high input impedance. In theory, this impedance is equal to the open-loop input resistance (typically 1M0 in a bipolar 741) multiplied by A_O/A. In practice, input impedance values of hundreds of megohms can easily be obtained in DC circuits such as those in *Figures 3* and *4*.

Figure 5 shows how the *Figure 3* circuit can be modified for use as an x10 non-inverting AC amplifier by removing the offset biasing network, connecting the non-inverting terminal to ground via biasing resistor R3, and connecting the input signal via a blocking capacitor. Note that gain-control resistors R1-R2 are isolated from ground via blocking capacitor C2, which has negligible impedance at practical operating frequencies; the voltage gain is thus determined by the ratios of R1 and R2, but the op-amp's inverting terminal is subjected to virtually 100% DC negative feedback, thus giving the circuit excellent DC stability. For optimum biasing, R3 should have the same value as R1.

Note that the input impedance of the *Figure 5* circuit equals the R3 value, and is limited to a few megohms by practical considerations. *Figure 6* shows how the basic circuit can be modified to give a very high input impedance (typically 50 megohms).

Here, the positions of C2 and R2 are transposed, and the low end of R3 is tied to the C2-R2 junction. As a consequence, near-identical operating (AC) signal voltages appear at both ends of R3, which thus passes negligible signal current and has an apparent impedance that is massively increased by this 'bootstrap' action.

In practice, the circuit's input impedance is typically limited to about 50 megohms by leakage impedances of the op-amp's socket and the PCB to which it is wired. Note that – for optimum DC biasing – the sum of the R2 and R3 values should equal R1. In practice, the R3 value can differ from this ideal by up to 30%, and an actual

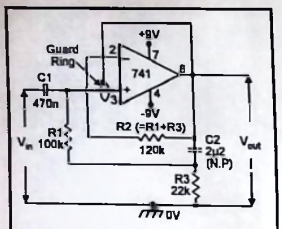

Figure 9. **AC voltage follower with 50M input impedance without the guard ring, or 500M with the guard ring.**

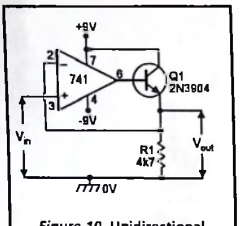

Figure 10. **Unidirectional DC voltage follower with boosted output-current drive.**

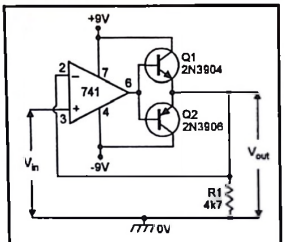

Figure 11. **Bidirectional DC voltage follower with boosted output-current drive.**

'high f_T' op-amps tend towards instability when used in the unity-gain mode and, in such cases, R1 should be given a value of 1k0 or greater to effectively reduce the circuit's bandwidth and thus enhance stability.

Figure 8 shows an AC version of the voltage follower. In this case, the input signal is DC-blocked via C1, and the op-amp's non-inverting terminal is tied to ground via R1, which determined the circuit's input impedance. Ideally, feedback resistor R2 should have the same value as R1. If R2 has a high value, however, it may significantly reduce the circuit's bandwidth. This problem can be overcome by shunting R2 with C2, as shown dotted. If the latter technique is used with a 'high f_T' op-amp, resistor R3 can be connected as shown to ensure circuit stability.

If a very high input impedance is required from an AC voltage follower, it can be obtained by using the basic configuration shown in *Figure 9*, in which R1 is 'bootstrapped' from the op-amp output via C2, thus raising its impedance to near-infinity. In practice, this circuit can easily give an input impedance of 50 megohms from a 741 op-amp; this limit being set by the leakage impedance of the op-amp's IC socket and the PCB.

If an even greater input impedance is needed, the area of PCB surrounding the op-amp input pin should be provided with a printed 'guard ring' that is driven from the op-amp output, as shown, so that the leakage impedances of the PCB, etc., are themselves bootstrapped and raised to near-infinite values. In this case, the *Figure 9* circuit gives an input impedance of about 500 megohms when used with a 741 op-amp, or even greater if an FET-input op-amp is used.

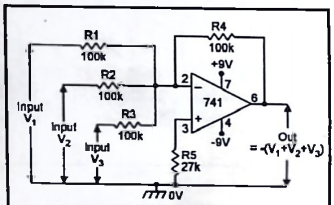

Figure 12. **Unity-gain inverting DC adder.**

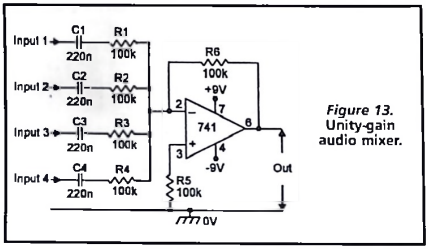

Figure 13. **Unity-gain audio mixer.**

value of 100k can be used in the *Figure 6* circuit, if desired.

VOLTAGE FOLLOWER CIRCUITS

A voltage follower circuit produces an output voltage that is identical to that of the input signal, but has a very high input impedance and a very low output impedance. The circuit actually functions as a unity-gain non-inverting amplifier with 100% negative feedback. *Figure 7* shows the idealized design of a precision voltage follower with offset biasing. Note that — for optimum biasing — feedback resistor R1 should have a value equal to the source resistance of the input signal.

In practice, the basic *Figure 7* circuit can often be greatly simplified. Eliminating the offset biasing network, for example, adds an error of only a few mV to the output of the op-amp. Again, the value of feedback resistor R1 can be varied from zero to 100k without greatly influencing the circuit's accuracy.

If an op-amp with a low f_T value (such as the 741) is used, the R1 value can usually be reduced to zero. Note, however, that many

CURRENT-BOOSTED 'FOLLOWER' CIRCUITS

Most op-amps can provide maximum output currents of only a few milliamps, and this is the current-driving limit of the voltage follower circuits in *Figures 7* to *9*. The current-driving capacity of a voltage follower can easily be increased, however, by wiring a simple or a complementary emitter follower current booster stage between the op-amp output and the final output terminal of the circuit, as shown in the basic designs

in *Figures 10* and *11*. Note that the base-emitter junctions of the transistors are wired into the negative feedback loop of the op-amp, to minimize the effects of junction non-linearity.

The *Figure 10* circuit is able to source large currents (via Q1), but can sink only relatively small ones (via R1). This circuit can thus be regarded as a unidirectional, positive-only, DC voltage follower.

The *Figure 11* circuit can both source (via Q1) and sink (via Q2) large output currents, and can be regarded as a bidirectional (positive and negative) voltage follower. In the simple form shown in the diagram, the circuit produces significant cross-over distortion as the output moves around the zero volts value. This distortion can be eliminated by suitably biasing Q1 and Q2.

In practice, the *Figure 10* and *11* circuits have maximum current-drive capacities of about 50mA, this figure being dictated by the low power ratings of the specified transistors. Greater drive capacity can be obtained by using alternative transistors.

ADDERS AND SUBTRACTORS

Figure 12 shows the circuit of a unity-gain analog DC voltage adder, which gives an inverted output voltage equal to the sum of the three input voltages. Input resistors R1 to R3 and feedback resistor R4 have identical values, so the circuit acts as a unity-gain inverting DC amplifier between each input terminal and the output. The current flowing in R4 is equal to the sum of the R1 to R3 currents, and the inverted output voltage is thus equal to the sum of the input voltages. In high-precision applications, the circuit can be provided with an offset nulling facility.

The *Figure 12* circuit is shown with three input connections, but can, in fact, be given any number of inputs (each with a value equal to R1), but in this case, the R5 value should (for optimum biasing) be altered to equal the parallel values of all other resistors. If required, the circuit can be made to give a voltage gain greater than unity by simply increasing the value of feedback resistor R4. The circuit can be used as a multi-input 'audio mixer' by AC-coupling the input signals and giving R5 the same value as the feedback resistor, as shown in the four-input circuit in *Figure 13*.

Figure 14 shows the circuit of a unity-gain DC differential amplifier, or analog subtractor, in which the output equals the difference between the two input signal voltages, i.e., equals $e_2 - e_1$. In this type of circuit, the component values are chosen such that R1/R2 =

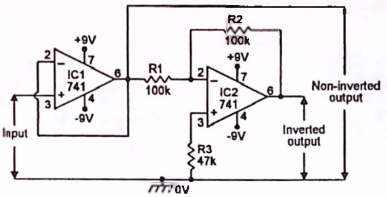

Figure 15. **Unity-gain balanced DC phase-splitter.**

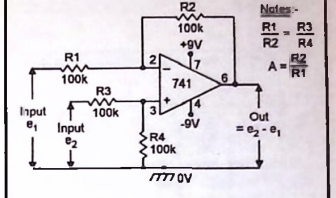

Figure 14. **Unity-gain DC differential amplifier, or subtractor.**

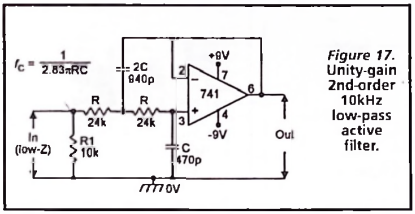

Figure 17. **Unity-gain 2nd-order 10kHz low-pass active filter.**

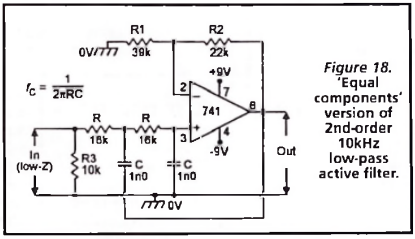

Figure 18. **'Equal components' version of 2nd-order 10kHz low-pass active filter.**

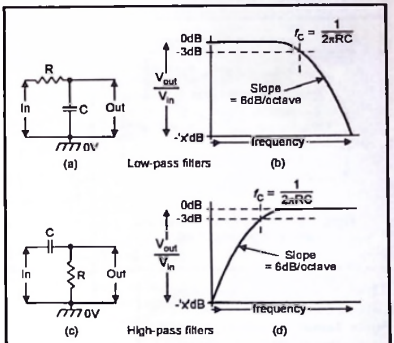

Figure 16. **Circuit and response curves of simple 1st-order R-C filters.**

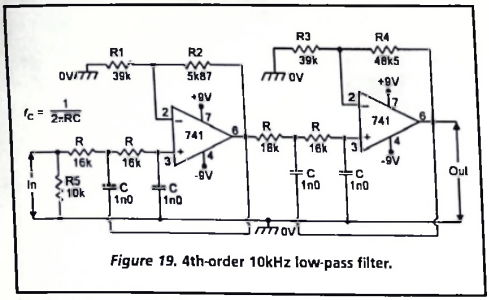

Figure 19. 4th-order 10kHz low-pass filter.

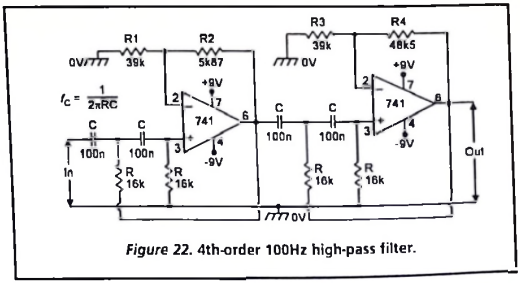

Figure 22. 4th-order 100Hz high-pass filter.

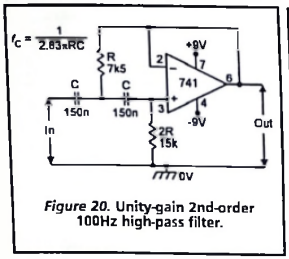

Figure 20. Unity-gain 2nd-order 100Hz high-pass filter.

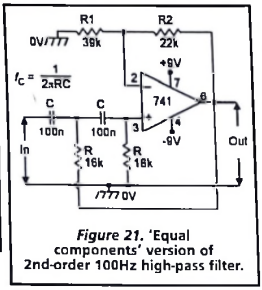

Figure 21. 'Equal components' version of 2nd-order 100Hz high-pass filter.

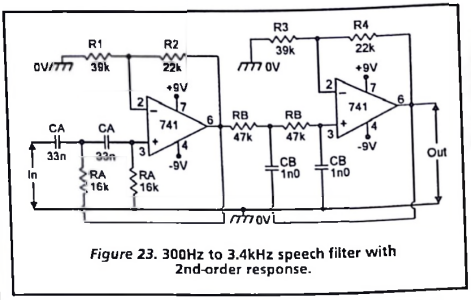

Figure 23. 300Hz to 3.4kHz speech filter with 2nd-order response.

R3/R4, in which case, the voltage gain, A, equals R2/R1. When — in *Figure 14* — R1 and R2 have equal values, the circuit gives unity overall gain, and thus acts as an analog subtractor.

BALANCED PHASE-SPLITTER

A phase-splitter has a pair of output terminals, which produce outputs that are identical in amplitude and form, but with one output phase-shifted by 180° (i.e., inverted) relative to the other. *Figure 15* shows an easy way of making a unity-gain balanced DC phase-splitter, using a pair of 741 op-amps.

Here, IC1 acts as a unity-gain non-inverting amplifier or voltage follower, and provides a buffered output signal that is identical to that of the input.

This output also provides the input drive to IC2, which acts as a unity-gain inverting amplifier, and provides the second output, which is inverted but is otherwise identical to the original input signal.

ACTIVE FILTERS

Filter circuits are used to reject unwanted frequencies and pass only those wanted by the designer. A simple R-C low-pass filter (*Figure 16(a)*) passes low-frequency signals, but rejects high-frequency ones.

The output falls by 3dB at a 'break' or 'cross-over' frequency (f_C) of $1/2\pi RC$), and then falls at a rate of 6dB/octave (= 20dB/decade) as the frequency is increased (see *Figure 16(b)*). Thus, a simple 1kHz filter gives roughly 12dB of rejection to a 4kHz signal, and 20dB to a 10kHz one.

A simple R-C high-pass filter (*Figure 16(c)*) passes high-frequency signals, but rejects low-frequency ones. The output is 3dB down at a break frequency of $1/2\pi RC$), and then falls at a 6dB/octave rate as the frequency is decreased below this value (*Figure 16(d)*). Thus, a simple 1kHz filter gives roughly 12dB of rejection to a 250Hz signal, or 20dB to a 100Hz signal.

Each of the above two filter circuits uses a single R-C stage, and is known as a '1st order' filter. If a number (n) of similar filters are effectively cascaded, the resulting circuit is known as an 'nth order' filter and has an output slope, beyond f_C, of (n x 6dB)/octave.

Thus, a 4th order 1kHz low-pass filter has a slope of 24dB/octave, and gives 48dB of rejection to a 4kHz signal, and 80dB to a 10kHz signal.

One way of effectively cascading such filters is to wire them into the feedback networks of suitable op-amp amplifiers; such circuits are known as 'active filters,' and *Figures 17* to *23* show practical examples of some of them.

ACTIVE FILTER CIRCUITS

Figure 17 shows the practical circuit and formula of a maximally-flat (Butterworth) unity-gain 2nd-order low-pass filter with a 10kHz break frequency. Its output falls off at a 12dB/octave rate beyond 10kHz, and is about 40dB down at 100kHz, and so on. To change the break frequency, simply change either the R or the C value in proportion to the frequency ratio relative to *Figure 17*; reduce the values by this ratio to increase the frequency, or increase them to reduce it. Thus, for 4kHz operation, increase the R values by a ratio of 10kHz/4kHz, or 2.5 times.

A minor snag with the *Figure 17* circuit is that one of its C values must be twice the value of the other, and this may demand odd component values. *Figure 18* shows an alternative 2nd-order 10kHz low-pass filter circuit that overcomes this snag and uses equal component values. Note here that the op-amp is designed to give a voltage gain (4.1dB in this case) via R1 and R2, which must have the values shown.

Figure 19 shows how two of these 'equal component' filters can be cascaded to make a 4th-order low-pass filter with a slope of 24dB/octave. Note in this case that gain-determining resistors R1/R2 have a ratio of 6.644, and R3/R4 have a ratio of 0.805, giving an overall voltage gain of 8.3dB. The odd values of R2 and R4 can be made up by series-connecting 5% resistors.

Figures 20 and *21* show unity-gain and 'equal component' versions respectively of 2nd-order 100Hz high-pass filters, and *Figure 22* shows a 4th-order 100Hz high-pass filter. The operating frequencies of these circuits, and those of *Figures 18* and *19*, can be altered in exactly the same way as in *Figure 17*, i.e., by increasing the R or C values to reduce the break frequency, or *vice versa*.

Finally, to complete this installment of the series, *Figure 23* shows how the *Figure 21* high-pass and *Figure 18* low-pass filters can be wired in series to make (with suitable component value changes) a 300Hz to 3.4kHz speech filter that gives 12dB/octave rejection to all signals outside of this range. In the case of the high-pass filter, the C values in *Figure 21* are reduced by a factor of three, to raise the break frequency from 100Hz to 300Hz and, in the case of the low-pass filter, the R values in *Figure 18* are increased by a factor of 2.94, to reduce the break frequency from 10kHz to 3.4kHz. **NV**

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Philadelphia 19110

TENNESSEE

Tower Books
2404 W. End Ave.
Nashville 37203
Tower Records
504 Opry Mills Dr.
Nashville 37214

TEXAS

BDL News, Inc.
809 Pierce
Houston 77002
Electronic Parts Outlet
3753-B Fondren Rd.
Houston 77063
Mouser Electronics
958 N. Main St.
Mansfield 76063
Tanner Electronics
1301 W. Beltline #105
Carrollton 75006
Tower Records
2403 Guadalupe St.
Austin 78705

VIRGINIA

Tower Records/Video
6200 Little River Turnpike
Alexandria 22312

4110 W. Ox Rd. #12124
Fairfax 22033

1601 Willow Lawn Dr.
Richmond 23230

8389 E. Leesburg Pike
Vienna 22182

WASHINGTON

A-B-C Communications, Inc.
17541 15th Ave. N.E.
Seattle 98155
Supertronix
16550 W. Valley Hwy.
Seattle 98188
Tower Books
10635 N.E. 8th St.
Bellevue 98004

20 Mercer St.
Seattle 98109

WISCONSIN

Amateur Electronic Supply, Inc.
5710 W. Good Hope Rd.
Milwaukee 53223

WYOMING

Western Test Systems
2701 Westland Ct. #B
Cheyenne 82001

Questions & Answers

TECH FORUM

This is a READER TO READER Column. All questions AND answers will be provided by Nuts & Volts readers and are intended to promote the exchange of ideas and provide assistance for solving problems of a technical nature. All questions submitted are subject to editing and will be published on a space available basis if deemed suitable to the publisher. All answers are submitted by readers and NO GUARANTEES WHATSOEVER are made by the publisher. The implementation of any answer printed in this column may require varying degrees of technical experience and should only be attempted by qualified individuals. Always use common sense and good judgement!

Don't forget to check out the new online electronics forums at the *Nuts & Volts* website. There are currently boards for discussing Robotics, Microcontrollers, Radio, Computers, CNC, and a General forum for discussing any electronic topic at all. We'll even add new dedicated boards for hot topics. Just let us know!

Want to get a jump on things before the magazine arrives? The Tech Forum questions are posted on our website on or before the first of each month. Unanswered questions from recent issues are there also.

Send all material to Nuts & Volts Magazine, 430 Princeland Court, Corona, CA 92879, OR fax to (909) 371-3052, OR E-Mail to forum@nutsvolts.com

QUESTIONS

My friend bought an older motel. The front desk switchboard for the room's telephones is an aging model with little or no tech support.

Is there a way we can use a desk phone, small laptop computer, and some kind of interface box as a substitute for the old console to control the six phone lines that enter the motel?

There are dedicated switchboards on the market, but at $25,000.00 a copy, some cheaper method needs to be found!

The software needs to switch calls between rooms and scan for an open line for outgoing calls.

8011 **Gordon McKittrick**
Havre, MT

Does someone have a schematic and information on how to build a logic clip?

I am hoping to be able to run it off of a rechargeable battery, and be able to plug it in and run it, and automatically recharge the battery at the same time.

8012 **Jason Rogers**
Paducah, KY

What is the wiring diagram for a ceiling fan with a four-position pull chain switch (off, high, medium, low)? What would happen if the wires for the speed changes were mixed up? Would it only affect the order or would it cause damage?

8013 **Ramon Eller**
Pittsburgh, PA

I found a page on Alta, Yahoo, or Sympatico and it told of an American university student with a lifelong love of electronics who invented a new way of sampling TV images to allow recombining them so as to get 3DTV. He applied for a provisional patent, was written up in some magazines, and has his prototype unit in the basement of his university.

I do not remember anything but these general facts. Can anyone help?

8014 **Tom Mooney**
via Internet

About 10 years ago, I remember there being a short craze on water-powered watches. I'm not sure what principle these worked on (I'm guessing certain electrodes pick up free electrons), but I would be interested in using it for my own projects.

Any information about this technology would be much appreciated. Perhaps someone remembers what company made the watches and how to get in touch with them.

8015 **Greville J. Kirk**
via Internet

Is there any way I can power a device already connected to the phone line (providing an audio signal), but also drawing power (6 VDC-60uA) directly from the phone line? A diagram would be greatly appreciated.

8016 **Dan Gherghor**
via Internet

I do electronic board repair for a textile mill. A young man whose father used to work with me came to me with a problem.

He overloaded the stereo with speakers and as soon as the power button is pressed, it shows protect, and 24 hours later when powered up, it goes through a display. I have used the buttons to clear the memory several times with no results.

I'm no TV or stereo repair man, but this kid believes in me. Sharp says take it to a repair shop. They quote $50-$250, but this kid doesn't have that kind of money.

I wish someone would tell me how to correct this problem. I would sure like to help this kid and I would appreciate someone coming to our rescue. I've been with Nuts & Volts for about 20 years and have seen it come a long way. I'm self-taught in electronics and try hard, but I know my limits.

8017 **Terry Crowe**
Woodruff, SC

ANSWERS

ANSWERS TO #7012 - JULY 2001

I have a PIC programmer, an Epic Plus from microEngineering Labs that's attached to my computer's LPT1 port. When the machine boots up, the BIOS sends data to the base address (presumably as a test to see if the port is really there).

The bits turn on my programmer in the worst way. The drivers are enabled and, if I forget to unplug the "wall-wart" supply, the regulators get very hot after awhile. I want to turn off the programmer automatically.

I need a way to write $0C to the base address ($0378) at bootup. I tried sending out the data using the ECHO command in the Autoexec.bat file, but because the programmer does not respond with the ACK bit, all I get is a Write Fault Error for LPT1. There's no intelligence on this programmer at all; it just sits there and does its thing.

Short of writing a BASIC program and compiling it into .exe code, I don't know how to send $0C to the base address. Any ideas?

#1 You don't need to write and compile a Basic program into a clumsy .EXE file. The simplest way to send a byte to a port is with an eight-byte .COM file containing the following: BA 78 03 B0 0C EE CD 20.

This corresponds to the following assembly code:

```
MOV DX,$0378 ; Load port address.
MOV AL,$0C ; Load output byte.
OUT DX,AL ; Output the byte.
INT $20 ; End the program.
```

You can create the eight-byte .COM file with Debug or with a simple Basic program. Here's a short Basic program to create the file:

```
OPEN "INITPIC.COM" FOR OUTPUT AS #1
  FOR I = 1 to 8
  READ B
  PRINT #1,CHR$(B);
  NEXT
```

ANSWER INFO

- Include the question number that appears directly below the question you are responding to.
- Payment of $25.00 will be sent if your answer is printed. Be sure to include your mailing address if responding by E-Mail or we can not send payment.
- Your name, city, and state, will be printed in the magazine, unless you notify us otherwise. If you want your email address printed also, indicate to that effect.
- The question number and a short summary of the original question will be printed above the answer.
- Unanswered questions from a past issue may still be responded to.
- Comments regarding answers printed in this column may be printed in the Reader Feedback section if space allows.

QUESTION INFO

TO BE CONSIDERED

All questions should relate to one or more of the following:
1) Circuit Design **3)** Problem Solving
2) Electronic Theory **4)** Other Similar Topics

INFORMATION/RESTRICTIONS

- No questions will be accepted that offer equipment for sale or equipment wanted to buy.
- Selected questions will be printed one time on a space available basis.
- Questions may be subject to editing.

HELPFUL HINTS

- Be brief but include all pertinent information. If no one knows what you're asking, you won't get any response (and we probably won't print it either).
- Write legibly (or type). If we can't read it, we'll throw it away.
- Include your Name, Address, Phone Number, and email. Only your name, city, and state will be published with the question, but we may need to contact you.

ANSWERS TO #7013 - JULY 2001

I am trying to repair a guitar amplifier by Gorilla Musical and need to find a company that carries the TDA2030 amp circuit and has a reasonal minimal order. Or, is there a substitute part?

#1 The TDA2030 is a chip designed in the 80s which found very widespread use in TVs, car stereo, and small musical instrument amplifiers of several brands.

It is an AF power amp with differential input, delivering 12-14 watts into a 4-ohm load, and 6-8 watts into an 8-ohm load.

If using a split power supply, a direct coupled circuit is possible. Some devices use two chips — in a bridge arrangement — for higher power. If the device has a single-ended power supply, the output will usually be coupled through an electrolytic capacitor, running in value from 500 uF to 2200 uF.

This should be commonly available from most any parts distributor, it crosses to ECG (NTE) 1380.

Many failures of this chip early on were due to poor application of heat-sink grease when the end device was manufactured. Most failures I have seen in musical instrument applications have resulted from too low a load impedance (the result of the musician bridging more speakers across the one in the amplifier cabinet).

Remember, keep your total speaker impedance at least 4 ohms. If your amp uses two of these in a bridge arrangement, you'd best replace both of them. If your amp uses a single ended supply, I'd at least check the output coupling capacitor (if there's any age on the unit, I'd go ahead and replace the capacitor while performing the chip replacement.

Phil Shewmaker
Louisville, KY

#2 The TDA2030 integrated amplifier can be directly replaced with ECG1380 or NTE1380.

One of the major distributors that should carry this part is Mouser Electronics. They do not require a minimum order and can be reached toll-free at 1-800-346-6873 when placing an order.

Glen Thome
Elyria, OH

#3 A quick Yahoo search turned up Audio Lab of Georgia www.datadart.com/ or phone 770 455.0571, fax 770 458 5727. The good news is they want all of $1.75 for the TDA2030. The bad news is shipping is another $6.00. Still desperate times may call for desperate measures.

Tom Tillander
Bay Village, OH

#4 You can find the TDA2030 at MCM Electronics (1-800-543-4330), for $2.11, plus a small order service charge of $2.95. A substitute part is NTE 1380 which you may find at a local electronics store.

Haim Sandel
Phoenix, AZ

#5 The TDA2030 is available from RadioShack.com as part number 901-0395, for $14.98 for one. The same part is available from any dealer in NTE/ECG parts as number 1380.

Russell Kincaid
Milford, NH

#6 Partsexress.com 1-800-338-0531, and mcmelectronics.com 1-800-543-4330, both have the IC TDA2030 for $2.06.

I am working on an audio Centron amp that needs the same IC. (I think some Peavey amps use this IC, too.)

Jon Garee
Newark, OH

```
CLOSE
DATA &HBA,&H78,&H03,&HB0
DATA &H0C,&HEE,&HCD,&H20
```

Some versions of Basic will create a nine-byte file with an extra $1A at the end, but the extra byte will do no harm. Simply invoke the file from AUTOEXEC.BAT and you're in business.

John J. Herro
Palm Bay, FL

#2 Unfortunately, you can't run a command in the autoexec.bat file to solve the problem. The autoexec.bat file runs before Windows is done loading and Windows will likely write a value to the printer port before it is done. (It did so on my computer.)

But there is good news! A batch file in the StartUp folder and a non-compiled two command Qbasic program will do the trick. Follow these steps.

1. Get a copy of Qbasic.exe and copy it to your root directory. (C:\) Qbasic was included with DOS 5. You probably still have it. Copy qbasic.hlp to C:\ too for your reference.
2. Start Qbasic and type these commands: OUT &H378,&H0C SYSTEM
3. Save this file as C:\fix_port.bas
4. Quit Qbasic.
5. Open Notepad.
6. Type this command:
   C:\qbasic.exe /run fix_port.bas
7. Save this file as C:\fix_it.bat
8. Use Windows Explorer to copy fix_it.bat to C:\Windows\Start Menu\Programs\StartUp
9. Right click on the copy of fix_it.bat that you just moved. Select "Properties." Select the "Program" tab. Click the "Close on exit" to place a check mark there.

Now when you start your computer, the batch file will run from the StartUp folder and write "0C" to "378." This should solve the problem. Qbasic will close, the batch file will close and the DOS window will close. You can manipulate the printer port data bits anyway you want.

Qbasic does not produce compiled programs. It is easy to use and quite a versatile tool for the hobbyist. I use a Qbasic program that I wrote and a simple interface in place of an oscillator to single step through some of my PIC projects. I use it as a debugging aid.

Jeff Scholz
Portland, OR

#3 What you need is a small .com program that writes the byte 0cH to the port directly instead of through the BIOS. This .com program can be created by using debug, if you have it loaded on your computer, using the script below.

Type this into a text editor and save it as pure text with the filename "epicport.scr." Make sure you include blank lines where shown:

```
a100
mov dx,378
mov al,0c
out dx,al
int 20
                (leave this line blank,
just type the enter key)
n epicport.com
r cx
8
w
q
```

Then issue the following command at the DOS prompt:

```
debug <epicport.scr [ENTER]
```

A file called "epicport.com" will be left in the current directory that will have the effect you need when run. If you don't have debug on your computer, I will email the program to you already assembled.

William Cooke
WRCooke@aol.com

The file epicport.com has been placed on the Nuts & Volts FTP site.

#4 One way to send 0x0C to port 0x378 is by invoking a .com file continging the following instructions:

```
mov     al,0C
mov     dx,0378
out dx,al
int  20
```

An easy way to create such a short program is using DEBUG.

Type the following lines (each terminated by the enter key, starting from the DOS command prompt. Each intra line whitespace is a single space character. The single embedded blank line is just that: type the enter key an extra time to produce it. I have left out the prompts for clarity. You can actually cd to wherever you want, but if it's not in your path, you'll have to specify its path in autoexec.bat, where you invoke the program. Clearly you can choose a different name than x0ctolpt if you so desire.

```
cd \
debug
a100
mov al,0c
mov dx,0378
out dx,al
int 20

rc
0008
nx0ctolpt.com
w
q
```

The 8 placed in CX is the number of bytes to write. We know that because at the time that you typed the blank line, it was prompting for the instruction to put at location 108, and we started at 100 (these are hex numbers). You now have a program named x0ctolpt.com that you can call from anywhere. Just for completeness, the hex bytes for this particular program (the procedure applies to other ports and other values) are:

B0, 0C, BA, 78, 03, EE, CD, 20

Or in decimal:

176, 12, 186, 120, 3, 238, 205, 20

Sadly, you can't use the "copy con foo.com" plus holding alt while typing the decimal for the character code trick, because the 03 is also control-C, and terminates the copy (at least it does in a DOS box under Windows-98), same for trying to echo the string redirected to a file. EDIT, NOTEPAD, and WORDPAD all have some problems trying to create such a file, but DEBUG comes free with every version of DOS and Windows that I've ever seen, so why sweat it?

Bill Freeman
via Internet

One-Button Electronic Security Lock

Lose a house key lately? Do you fumble through a large ring of keys to unlock the basement door? This simple push-button security lock solves that problem — and more.

by Tim Hamel

Combination locks — with their keyless operation — find widespread use in secured entry doors. No longer do persons with access to more than one locked door have to look like a security guard with multiple key rings.

The electronic combination lock goes one better by replacing the mechanical twist dial with push buttons — plus their combinations can be changed effortlessly should the code become compromised.

Despite these advantages, electronic combination locks have not made a big impact on the security market because they are limited by the very device that makes them desirable: the keypad. The keypad, an integral part of the system, is vulnerable to vandalism and tampering. Furthermore, it requires electrical power and multi-wire connecting cables, which complicates the installation and increases overall cost.

In this article, I'll show you how to make a single-button electronic security lock that provides all the benefits of the keypad version — but without the keypad!

Ding, Dong ... Doorbell Calling!

That's right, no keypad needed. A simple doorbell switch is used instead.

The theory of operation is identical to that of Morse Code communications. By tapping out a code using short and long presses of the doorbell, we can create "passwords" that, when deciphered, can be used to unlock a door.

For example, instead of entering 1234 into a keypad to unlatch the door, the one-button lock lets us enter the phrase "open sesame" to open the door. Actually, the code doesn't have to be that verbose. A simple string of eight or fewer dots and dashes is more than enough to make the system highly secure. Moreover, the doorbell button needs no power, making it absolutely tamperproof.

And if that isn't enough to get your attention, the lock uses a mere handful of parts — the main component being a common PIC microcontroller. Throw in a relay, a transistor, and a half-dozen passive devices and you have a one-button, fully programmable, electronic security lock (see Figure 1).

Wait! Don't Hang Up ... Read On!

Don't turn the page because I said this is a PIC-based microcontroller project. The original design didn't start out with a PIC in mind, it just evolved that way.

I've seen a lot of really neat projects I'd like to build, only to discover they are "computer" based — using proprietary code and parts. So I feel your fear.

But don't shy away. Even though I went to a PIC for the final

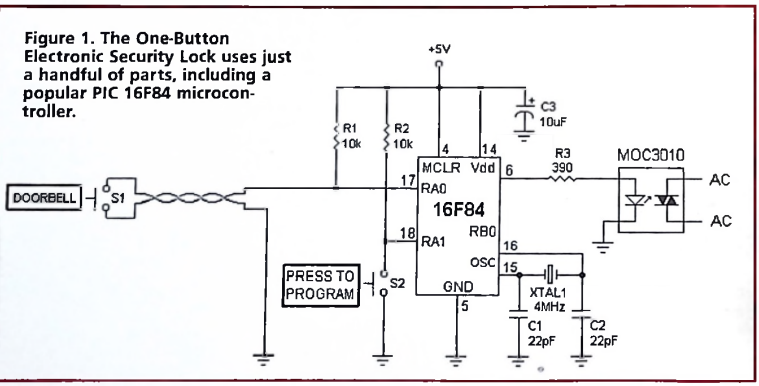


Figure 1. The One-Button Electronic Security Lock uses just a handful of parts, including a popular PIC 16F84 microcontroller.

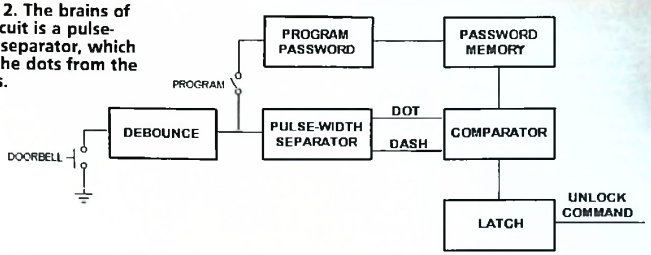
solution, it ended up that way simply because the PIC eliminates eight complex logic chips that I had to use in the original design. The PIC not only reduces part count, it makes the circuit more reliable and leaves the design open to future improvements.

The programming is easy, as you can see in Listing 1. If you'd rather not transcribe the code from this listing, you can download the program from *Nuts & Volts* web site at www.nutsvolts.com under the file name PIC_LOCK.TXT.

If neither appeals to you, a programmed PIC is also available (see Parts List) for little more than the cost of the unprogrammed PIC itself.

This is undoubtedly the hardest part of this project – deciding which option to choose.

Figure 2. The brains of the circuit is a pulse-width separator, which sorts the dots from the dashes.



How It Works

Like binary communications, Morse Code depends on two simple "states of being." The two states are either a short blast of signal (dot) or a longer one (dash). By using unique combinations of the two, the Morse Code can create any letter, word, or phrase. The signal can be a current through a relay – the method used for the original Western Union telegrams – or an audio tone, as is the case of wireless radio. If you're not familiar with Morse Code, it's the same "language" used by ships when they send an SOS message

The software that controls the doorbell lock is actually quite simple. Different sections in the code are named after their respective functions in the flow chart (Figure 1), which makes following the bouncing semicolon (;programming comments) much easier.

When the PIC first receives power, it jumps to the "Main" routine. In this routine, default security keys are stored and the PIC ports are initialized to input/output. The program then passes control to the "tstb" routine, which is just a constant loop that monitors the buttons (S1 and S2) for activity.

When it spots a key press, whether it be the "Press to Program" button or the doorbell, the switch is debounced. As said earlier, mechanical switches don't switch from high to ground in one clean swoop. Instead, they bounce, which the PIC interprets as multiple presses. In order to cure this, the button presses are routed to the "Debounce" routine. Button bounce usually doesn't last more than 20mS (1/50th of a second), so I wait for 20mS and check the button again. If, after 20mS, the button is still at a logic low (zero volts), the PIC assumes it's a legit button press.

Depending on which switch is pressed, the program enters one of two routines: one for programming a new password, "prgm," and another for password check for entry, "cmp." The next step is to measure the time of the doorbell button press to determine if it's a dot or a dash. This is the responsibility of the "tmit" routine. This routine checks the doorbell button every 20mS. If the button is still low, a counter is incremented. When the button is released, the input is pulled high (+5 volts) via a 10k resistor. The "tmit" routine then jumps to the "btfsc PORTA, 0" line. What this says is, "Bit Test File, Skip if Clear," which – in our case – it would be a logic high and the next line "goto test" will be the next instruction. Had the button still been low, the "goto test" line would have been skipped.

The program now goes to the "test" routine, where everything starts all over.

```
;=====Security Doorbell=====
;Author: Tim Hamel
;Date: 12/20/00
;Basic Operation:
;This little device will activate a relay when the correct
;code is entered in a morse-code fashion.
;===========================
;
d1      equ     15
d2      equ     16
d3      equ     17
count   equ     18
x       equ     19
key     equ     20              ;The key we use
inp     equ     21              ;the key the user entered
tmr     equ     22
z       equ     24
mkcnt   equ     23
r       equ     25

        org 0
        goto main


;=====4mS Delay=======
dly4    movlw   0x1c
        movwf   d1
Delay_00
        movlw   0x2e
        movwf   d2
Delay_01
        decfsz  d2, f
        goto    Delay_01
        decfsz  d1, f
        goto    Delay_00

        movlw   0x07
        movwf   d1
Delay_10
        decfsz  d1, f
        goto    Delay_10
        nop
        return
;===========================

;==20mS Delay – Uses 4mS delay routine=======

dly20   movlw   .5
        movwf   tmr
dly20a  call    dly4
        decfsz  tmr,1
        goto    dly20a
        return
;===========================

;=====Master-Key Programming Routine=====
;
prgm    bsf     PORTB,0         ;Turn on LED
        btfsc   PORTA,1         ;Debounce the PGM switch
        goto    tstb
        call    dly20

        btfsc   PORTA,1         ;Finishing up the debounce
        goto    tstb
        goto    gcode           ;If in fact the PGM switch is pressed,
                                ;enter programming mode.

gcode   call    dly20           ;delay....
        btfsc   PORTA, 0        ;Was the enter switch pressed?
        goto    tstt            ;No...
        incf    mkcnt,f         ;Yes, increment counter
                                ;each increment = 20mS
        goto    gcode           ;Do it all over

tstt    movf    x,w             ;x = 15, and 15 x 20mS = 300mS
        subwf   mkcnt,w         ;Simple compare routine
        btfsc   STATUS, C       ;If the Carry bit is clear, button < 300mS
        goto    stone           ;if the bit is set, button > 300mS
        rlf     inp,f
        goto    wt5s

stone   rlf     inp,f           ;Store a 1


wt5s    movlw   .5              ;wait 5 seconds for inactivity
        movwf   r

wt3     movlw   .250            ;4mS delay is called 250 times to = 1S
        movwf   tmr

wait4   call    dly4
        btfsc   PORTA,0
        goto    wait3
        clrf    mkcnt
        goto    gcode

wait3   decfsz  tmr,1
        goto    wait4
        decfsz  r,1
```

Continued next page

(dot-dot-dot ... dash-dash-dash ... dot-dot-dot). In binary format, this would be something like 000111000.

Okay, this encoded lock won't save a Titanic-class ship from sinking, but it does provide a security measure that rivals other, more sophisticated methods, like RFID (radio-frequency identification) cards.

Each time you press the doorbell switch it grounds the input of the PIC chip (Figure 2). Like most mechanical switches, doorbell switches suffer "bouncing" of the contacts until they settle in place. Consequently, the push button is debounced to prevent false inputs.

The pulse then goes to a pulse-width separator where the width of the pulse is measured. If the pulse width is less than 300 mS (about 1/3 second), it's decoded as a dot; if it's greater than 300 mS, it's decoded as a dash. This value is stored in a latch register. The next doorbell press is then processed and stored in the latch register. And so it goes.

After one second of doorbell inactivity, the PIC processor assumes the user has finished entering the password and compares the value stored in the latch register to the password stored in the PIC's onboard memory. If they are equal, solid-state relay MOC3010 is turned on for one second — but that one second is programmable; you can stretch it to however long you want. If they aren't equal, the latch register is cleared and the system is reset.

Pressing S2 places the PIC in the program mode, which allows you to enter a new password. As the new password is entered, it's processed by the pulse-width separator and clocked into the memory. If there is no doorbell input for five seconds, the new password is locked into place and the system goes back to password entry lock mode.

Construction

Construction of the PIC board

Parts List

Passive
R1, R2 — 10k
R3 — 390 ohms
C1, C2 — 22pF
C3 — 10uF, 10V

Semiconductors
MOC3010 optoisolator
PIC 16F84 microcontroller

Misc.
S1 — Doorbell switch
S2 — SPST, NO momentary push-button switch
XTAL1 — 4MHz crystal
Enclosure

Power Supply Parts
9VDC, 100 mA wallwart
78L05 regulator
0.33uF ceramic capacitor
0.1uF tantalum capacitor
12VAC transformer (for latch release)

SPST, NO momentary push-button switch
FW bridge, 50V @ 1A (for DC latch release only)
Latch release (can adapt car doorlock solenoid)

A programmed PIC microcontroller for the One-Button Electronic Security Lock is available from **PIC Projex, 1283 Fir Acres Dr., Eugene, OR 97401-1811.** Price is $12.00, shipping and handling included (US and Canada), by check or money order. No cash please.

```
        goto    wt3
        movfw   inp             ;After 5 seconds of no button presses,
                                ;we can assume the user is done
                                ;storing the master-key
        movwf   key
        clrf    inp
        bcf     PORTB,0         ;Turn off LED and exit programming mode.
        goto    tstb

;=======

;==Debounce Routine==
dbnc    btfsc   PORTA, 0        ;Test PORTA, bit 0, is it logic low?
        goto    tstb            ;No, line noise, return to testing.
        call    dly20           ;Yes, delay for 20mS

        btfsc   PORTA, 0
        goto    tstb            ;Nope, false press..crazy button
        goto    tmit            ;Button held for > 20mS - it's valid

;=======

;==Pulse-length timer==
;Determines length of button press.
;=
tmit    call    dly20           ;Time the button press length
        btfsc   PORTA, 0
        goto    test            ;Time button release pulse-length
        incf    count,f         ;Increment counter, again, 20mS
        goto    tmit

;=======

tstb    clrf    count           ;Just waiting for a button press here
        btfsc   PORTA, 0
        goto    tsts
        goto    dbnc

tsts    btfsc   PORTA,1         ;Here, we're testing to see if the
                                ;password program button is pressed
        goto    tstb
        goto    prgm

main
        movlw   .26             ;Not gonna happen, default to security
        movwf   key
        movlw   .15             ;This is the value that determines how
                                ;long the pulse-length is.
        movwf   x
        movlw   0
        TRIS    PORTB           ;PORTB=Output
        clrf    PORTB
        movlw   3               ;Make PORTA inputs, where the switches are
        tris    PORTA
```

```
        goto    tstb

;Same thing as up there ^^^, determine the button press
;pulse-length. I probably could've made this a "function"
;and just do a "call" instead of goto.

test
        movf    x,w
        subwf   count,w
        btfsc   STATUS, C
        goto    isone
        rlf     inp,f
        goto    wait

isone   rlf     inp,f

wait    movlw   .250            ;Wait 1S after the last button press,
                                ;if no presses, assume user is done
        movwf   tmr

wait2   call    dly4
        btfsc   PORTA,0
        goto    wait1
        goto    tstb

wait1   decfsz  tmr,1
        goto    wait2
        goto    cmp

cmp     movf    inp, w          ;The "Master" algorithm! All we do is
                                ;compare the input to the key, if they're
                                ;equal, we turn on the LED (relay)
        xorwf   key, w
        btfsc   STATUS, Z
        goto    bon             ;If they're equal, clear the input
                                ;register and turn on the LED.
                                ;If not, clear the input and start over...
        clrf    inp
        clrf    count
        goto    tstb

                                ;The rest just turns on the LED (or relay)
                                ;for 1 sec. Then we go back to square one
bon     clrf    inp
        bsf     PORTB,0
        movlw   .50
        movwf   z

bon1    call    dly20
        decfsz  z,1
        goto    bon1
        bcf     PORTB,0
        goto    tstb
        end
```

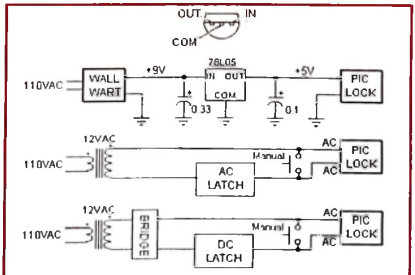


Figure 5. This is how to wire the Security Lock to power an electrical door latch. The wallwart should be rated 9 volts at 100 mA.

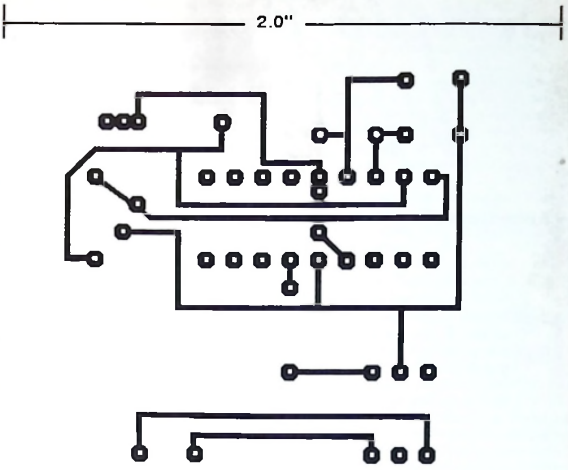


Figure 3. A foil pattern of the Security Lock printed circuit board. Actual size is as specified.

is a one-night project.

Because there are few critical components in this design, it lends itself well to many construction methods. The only critical parts are the 4-MHz crystal and its associated caps, which have to be as close to the PIC chip as possible. While it's not the only answer, I built my lock using the printed circuit board shown in Figure 3.

However, if you opt to use the lock with a line-operated load (110VAC), there is a risk of shock because the AC and DC are on the same board. Despite the isolation provided by the MOC3010 optoisolator, both lethal AC and harmless DC voltages can reside within millimeters of each other.

Should you grasp the board while it's plugged into the wall ... hellllooow! (Boy, talk about a wake up call!) Short of operating 12- or 24-volt latches, you're going to run that risk. You will notice, though, that I have separated the two as far apart as possible. (See Parts Layout, Figure 4.)

The schematic in Figure 5 shows the safe way to wire low-voltage solenoids, using either AC or DC actuators. Surplus solenoids can be found at many mail order outlets, like All Electronics (800-826-5432; www.allelectronics.com). Or go to a auto wrecking yard and buy a doorlock solenoid.

The power requirements for the controller are very light and not critical. The circuit will work at voltages between 3 and 6 volts, and draws less than 2 mA at 5 volts.

This permits battery operation; three AA-cell batteries will power the lock for about 90 days. Or you can use a small wallwart transformer with an external voltage regulator (see Figure 5). Make sure you use a DC output wallwart, and not an AC wallwart.

Any suitable enclosure will work, and the one you select depends on your choice of the power supply and placement of S2, the password program switch. I used a small plastic box with an external wallwart, them mounted S2 and a second S1 (parallel with the doorbell) on the front panel of the box.

This way, I don't have to run outside the door to reprogram the password. I also mounted the manual override switch on the front panel, so that I can let in visitors from control central.

The doorbell switch can be of any style that pleases you. Moreover, you don't have to buy twisted bell wire like that used with conventional doorbells. Leftover telephone wire works just as well, including unused wires that may already be in place.

Safe And Secure

That's all there is to it. Now there are no keys or keycards t lose or unlawfully duplicate.

Best of all, it's a very secur lock and the project is easy to build — even for a beginner. **NV**

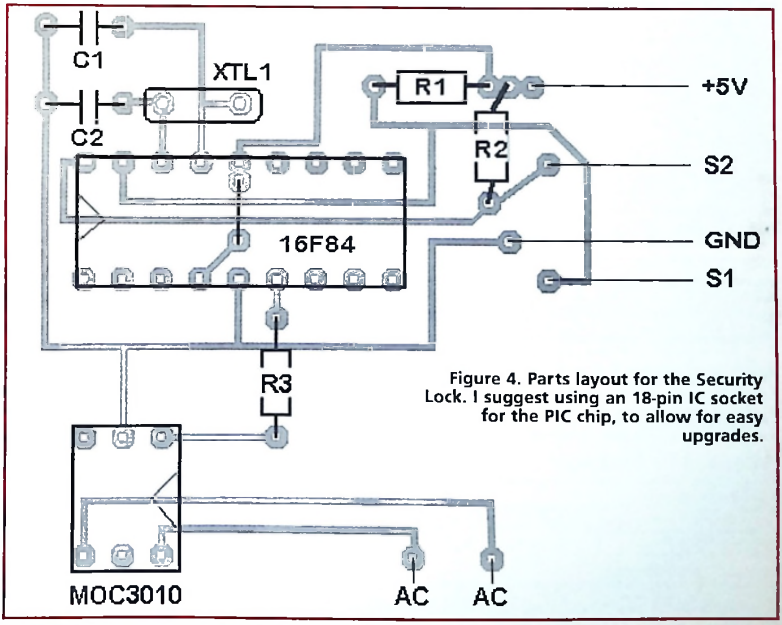


Figure 4. Parts layout for the Security Lock. I suggest using an 18-pin IC socket for the PIC chip, to allow for easy upgrades.

Simple Printed Circuit Boards Using An Inkjet Printer

by Kerry Barlow

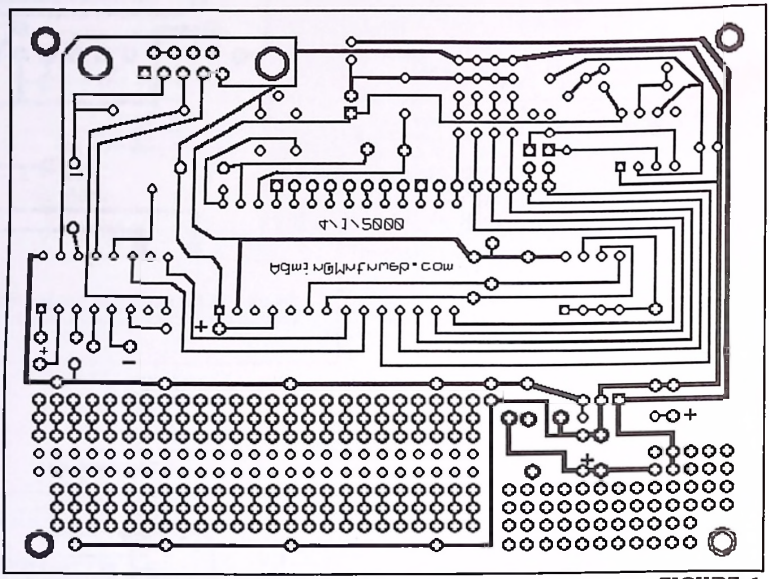


FIGURE 1

For many years, I have wanted to make my very own printed circuit boards. Many times, electronic circuits in magazines either require a circuit board to be used, or are too complicated to wire wrap. Commonly, a printed circuit is already in the magazine article, however, how do you take the printed circuit from the magazine, and transfer it to a copper board?

Many articles have been printed on some steps of this process, but critical steps may be missing or glossed over. The majority of articles written use laser printers for the artwork. This is not necessary. Using the method outlined here, a person can use a common inkjet printer, or even an old ribbon printer — if it has sheet-feed capability — to print the artwork.

Fancy heated acid tanks, expensive UV bulbs, expensive programs, and laser printers are not necessary for small quantities of boards. If you do make many boards, you may refer to the excellent heated etching tank article by Larry Ball in the April '98, *Nuts & Volts*.

The first step is obvious — you need an electronic circuit. This can be acquired from the magazine itself, or you will want to design your own board. If you use the circuit from the magazine, you will have to scan the image into your computer using a standard flatbed scanner. A page scanner could, of course, be used if you could tear the page out of the magazine and it fit properly into the page scanner. Whichever scanner you use, save the image in a standard graphic format. The saved format is not critical, as it is only dependant on the program you will use to print out to your printer.

To design your own circuit, you may use any program you wish, however, I use Express PCB, available for free download at http://www.expresspcb.com/.

Express PCB was picked for its ease of use as the main criteria. I have tried many other circuit programs and the complexity of them is overwhelming. When you only make

Simple Printed Circuit Boards Using An Inkjet Printer

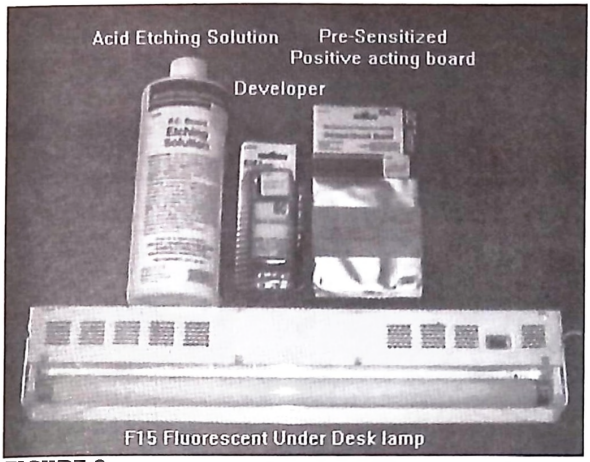


FIGURE 2

two boards a year, you will look forward to simplicity. Express PCB has no fancy layout or auto-routers; you must lay the tracks by hand on screen.

This is not as difficult as it may seem. Figure 1 shows a single-sided circuit with four ICs, RS232 jacks, switches, and dozens of support components all in a 3" x 4" form size. If you are not picky about looks or overall size of your circuit, you do not even have to get fancy with fitting many components into a small size.

It is not my intention to go into detail on using Express PCB, however, I wish to point out some easily made mistakes when designing a circuit. For further reading on Express PCB, refer to the June '98 *Nuts & Volts* article by David Schneider and Stanley Reifel.

Express PCB has a very good "Tips for Making PC Boards'" page on their website. Some of my hints differ from theirs in marginal ways only.

The first step when you begin to design your circuit using Express PCB is to set your board size. If you do not set a basic board size and end up having to shift components, you may run into a board edge that you cannot move.

In Express PCB, you may drag all of the board corners to size except for the upper left corner. This is locked into position. Go to the VIEW command, select OPTIONS, and then be sure "show grid" is turned on, and the grid is set for .1" spacing; also set your "snap to" grid spacing to .05". Many electrical components are based on .1" spacing.

For now, you may use the default colors that Express PCB picks. You will notice as you drag your mouse over the screen, in the lower status bar it will show you an inch measurement relating to where you are on the circuit board. You can use this to set a board size to 3"x 4" or whatever size you wish.

For signal traces, use a size of .012" for low power traces, and use a size of .025" for higher power traces. Do not use traces smaller than .012"; you will begin to have problems when etching the boards if you use the very small traces.

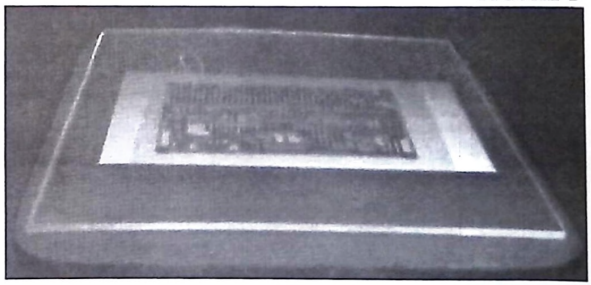
Place all of your ICs first on the board, lining them up so that the #1 pins are all facing the same direction. Leave ½" space on the left of your first IC, between the IC and the board edge. This will give you some room to route traces along the edge. You can leave as much room as you wish on the left; you can always cut off the left side of the board or, of course, not even develop the left section of the board when you are finished.

Now begin routing the traces between the ICs as required. A pitfall here is that you must be sure you are laying *all* of your traces on the same side of the board if you are making a single layer board. Express PCB uses a green default color for the bottom layer and red for the top layer. If you are making a two-layer board, you will know to lay traces as appropriate.

For pad sizes, use .065 round hole sizes if you are placing them manually. Express PCB has many built-in components, but sometimes you just need to place your own pads. Don't forget if you are making a single layer board, items are reversed, you are designing the copper of the board; try to think of your component as being laid on the monitor screen with its pins projecting inside the monitor.

It has been said in some articles not to use square corners on your traces. This is good practice, however, I have used square corners and have never seen a problem after etching. Refer to Figure 1 to see a circuit designed by hand with both square and diagonal corners. Notice the narrow traces for signal paths and the wider traces for ground and

FIGURE 3



Simple Printed Circuit Boards Using An Inkjet Printer

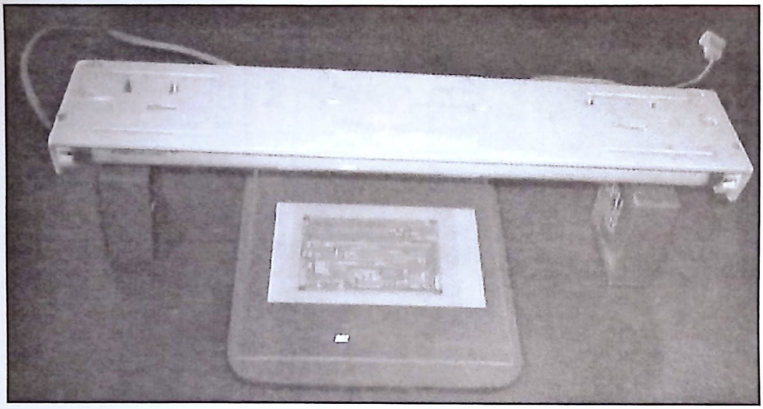


FIGURE 4

power paths, the orientation of the text, and the border around the entire circuit. This border will help in placing the transparency on your copper board. The border also helps in measuring the circuit to size after you print it out.

There very well may be some non-standard wiring patterns used or non-perfect circuits, but it is not the intent of this article to examine an electrical circuit. The circuit does work nicely however, and it has never given me problems. If there is interest, a description and details could be written in a follow-up article.

Do not be ashamed to lay out one trace, and then make a mark on your schematic to remind you, that you have actually created that trace. With 50 or more lines on a schematic, it can be easy to forget one of the connections.

Sometimes, the "snap to" grid will drive you nuts, especially when trying to fit many traces into a small space. Turn this feature on and off throughout your designs, depending on your circuit. You can easily fit a trace in-between the .1" grid spacing if you wish to.

Be aware of the actual part size when laying out your board. Some components have a very large footprint, such as switches, jacks, plugs, crystals, and capacitors. Be sure you leave enough room around the component so that your parts do not jam up against each other. Leave room for air cooling around large power resistors or audio ICs.

If you wish to have any text on your board, you may type in some text and actually etch it out of copper. This method may be used to print your name and board revisions. Use the text option that shows a little man upside down standing on his head. This will give the correct format after etching for legible text.

Don't forget a final option. If you wish to have many boards made, send in your artwork to Express PCB and have them etch and drill the boards for you.

Express PCB does not have a method to easily save your artwork. When you save a circuit, Express PCB will put grid dots on your artwork; this will not work for etching circuits. To get around this problem, you may simply take a screen capture and save it to a file.

You will need to turn off all corners, set your copper color to black, and set board edges to black also. Be sure to set your board size back to its correct zoom size so that 1" is exactly 1", not shrunk or enlarged.

You will now see on screen a conventional circuit board in black. Do a screen capture now by using the Print Screen key on your keyboard. This will save it to the clipboard. Paste this clipboard image into a graphic program of your choosing. I use "LviewPro" version 1.0, but any one of many graphic programs will do. Resolution is not a problem to worry about: my 3" x 4" board comes out to a 569 x 426 pixel size image on screen.

Using LviewPro select Edit, and then Paste. Now you will need to crop your image to size. This gets rid of unwanted screen artifacts around your artwork. If you have not done so yet, in LviewPro version 1, select Edit, then Paste, and you will see your artwork on screen.

Using your mouse, drag rubber band edges around your artwork until you see a nice flashing box surrounding only the artwork itself. To do this, click your left mouse button on the upper left corner of your artwork, hold the button down, slide your mouse to the lower right corner, and release the button. Now again select Edit, then crop, and you should see only your artwork in the window. You may now select File, Save, and save your image.

You may refer to the Parts List for a location to download LviewPro. I use version 1.0 that is available at my website http://MntnWeb.Com/

FIGURE 5

Tips for Successful Circuit Boards

1) Set your border to size before laying out any components on the board.
2) Print on the smooth side of the transparency, not the glue-based side.
3) Do not over expose or under expose your boards. Follow the manufacturer's time instructions.
4) Be sure your artwork has perfect traces before developing; no grainy lines or broken traces.
5) Ensure your artwork is orientated correctly before developing under the lamp.
6) Traces smaller than .012 are not recommended.
7) Use larger size traces for power and ground planes.
8) Leave room on your board for the actual size of the components, so they do not jam together.
9) Print out a plain paper copy of your design and place your components on it for testing.
10) When cutting boards on a band saw, place the plastic/copper side up, so that the saw teeth cut down and into the copper.
11) Be sure the ink is good in the printer; you want nice dark jet-black traces after print-out.
12) Continuously agitate the developer and the acid while processing the board.
13) The instant the last drops of copper have been etched from the board, remove it from the acid and wash the board. You do not want to over-etch the board.
14) Acid and developer may be reused many times. Store them in glass containers.
15) Do not move the board during the time it is developing under the UV lamp source.
16) Warm your acid to improve its performance.
17) Be careful while drilling pads to ensure you do not tear loose a trace.
18) Fine wire wrap may be used to repair a broken trace. Jumper it between your connections (RadioShack 278-501).
19) Etch resist pens may be used to repair a trace before developing (RadioShack RSU10446243).
20) Handle the board only by its edges before developing. Avoid touching photosensitive surfaces.
21) When drying the board after developing and etching, gently dry the board or air-dry it. Rubbing hard with a towel may remove small traces.
22) Do not place traces close to board edges. Leave some space at the edge of your board.

Simple Printed Circuit Boards Using An Inkjet Printer

Printed Circuit Board Overall Steps

1) Design your circuit or obtain one from a magazine.

2) Transfer the circuit into a drawing program. Use a scanner or a screen capture method by using the Print Screen key. (LviewPro works nicely.)

3) Crop the image so that you only have your artwork on screen.

4) Reverse the image or mirror the image as is necessary for printout (LviewPro).

5) Save the image.

6) Print the artwork onto plain paper and check your parts placement (LviewPro or PhotoPrinter).

7) Print the board onto a transparency to its measured size. An inkjet printer works very nice (PhotoPrinter).

8) Examine your transparency; use a magnifying glass, if necessary. You want jet-black traces, no unwanted connections, no porosity in the traces.

9) Remove the UV shield from the copper board (plastic film protector).

10) Place the transparency over the pre-sensitized board aligned correctly; text will be legible.

11) Place glass over the transparency to hold it tight against the circuit board.

12) Illuminate the board under an UV source. A F15 household desk lamp works nicely.

13) Do not move the board at any time during the illumination step.

14) Wear safety glasses and gloves.

15) Develop the board. Constantly and gently agitate the board.

16) Wash the board, and dry it gently.

17) Etch the board. Warm your acid, and constantly agitate the board.

18) Wash the board again to remove acid.

19) Drill the board.

20) Solder components.

Software.htm; it is much simpler and easier to use.

Let us begin the actual process of printing the circuit and etching it. The basic steps are as follows: Print the board onto a transparency. Place the transparency over a board. Develop the board using pre-sensitized copper boards. Develop the board and rinse the board under water. Acid etch the board. Drill the board. Solder the components. (You may also refer to the Printed Circuit Board Overall Steps sidebar.)

For this method, you must use pre-sensitized positive (+) acting circuit boards. These boards come in a special tin-foil type bag and have a special coating on them. You may use either the phenolic or the epoxy glass types. You may also purchase single-sided or double-sided boards. Do not remove them from their bag until you are ready to use them. These boards are available at any store that sells conventional circuit boards. Please refer to the Parts List for necessary items. The major parts are shown in Figure 2.

Step 1: Print the board onto a transparency. Now that you have the artwork in your computer, you may use an inkjet printer to print out the artwork. (You can, of course, use any printer.) Print your artwork onto plain white paper the first time. This will allow you to place the components onto the artwork, you can see if everything fits, and it is easy to tell if you have any bad traces. (You want a program that will allow you to print the same size as the actual artwork.) Refer to Figure 1.

If you designed a 3" x 4" board, you want to set your program's output to print to 3" x 4". Sometimes a graphic program will print out to DPI (dots per inch) and the artwork will come out tiny on the printer. Obviously, you do not want that. I use a program called PhotoPrinter. This program will take any photo or image and print it to a printer in any size you wish using inches or the metric system for output sizes.

This program is listed in the Parts List. If you download the program from my website, please view the readme.txt file. PhotoPrinter is very easy to use.

Start PhotoPrinter and select your artwork that was saved using your graphics program (LviewPro). Select Next and set your printer output size, either in inches or mm. You will need to check the inch box to select inch sizes. You may also save a predefined board size here. Select Next again and you see a screen ask-

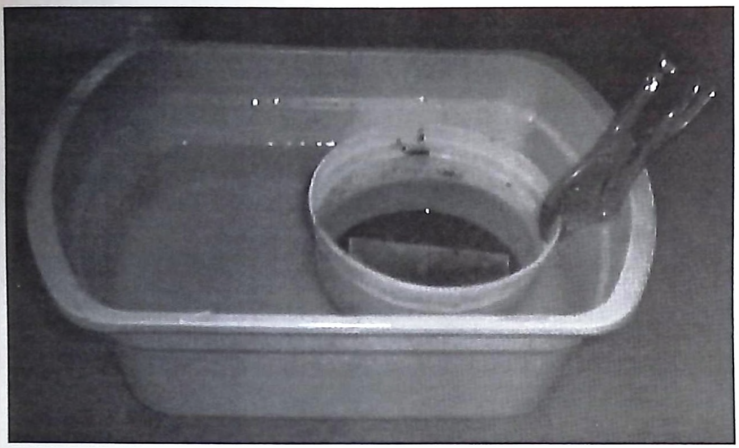


FIGURE 6

ing how many times you wish to print your output; just select Next again. Now you see a landscape or portrait selection screen. Unless your board is huge, simply select Next. If you like the preview shown on screen, you may click on the final Next button and your printer will do its job. This process is all easier to do than to say. It really is very simple. You may use this program to print to standard paper, as well as to the transparency.

If you have printed out to standard paper, and are happy with your image, you may now print out your artwork to a transparency. Some transparencies have a glue side, others are plain plastic. Depending on your printer, you will have to determine how to print out the artwork so that the image comes out aligned properly for etching. Here again, printing on plain paper makes things handy for you.

Do not print on the glue side, use the smooth side of glue-based transparencies. You can wet your finger and touch the transparency to see which side is sticky. Use the opposite side to print on. The gluey side is porous, and can cause small pinholes in your artwork traces, causing broken circuit paths.

When you have your artwork on the transparency, you will want it aligned so that any text is now legible, and the IC #1 pins are orientated properly. It is easy to be confused at this point. A method you may use to determine proper orientation is to place the transparency over the copper of a board with any text legible, then flip it all upside down and look up underneath the board. Imagine if you then placed an IC onto the topside of the board, and its pins stuck downwards through the holes and into the transparency. The etching should be on the bottom of the copper and aligned correctly.

For two-layer boards, you must be sure that the layers align properly with each other when they have been printed out. When looking at your artwork, be sure you have nice clean, dark, jet-black looking traces on the transparency. If you see any graininess or pinholes in the traces, they will show up when etched, as well. Don't hesitate to look at your board through a magnifying glass to examine the tiny traces. You want a perfect-looking printout at this step.

Step 2: Place the transparency over a board. You do not always need to buy circuit boards in exactly the size you need for your project. You may buy a board that is 6" x 4" and cut that into three boards of 2" x 4" size. Be sure if you cut a board to place unused boards back in their light-sealed bags when not used. Mine are cut on a small band saw.

Place the board with the white peel-off paper facing up so that the teeth push down, cutting into the copper side. Other people use a Dremel drill or Moto-Tool to cut their boards. A handsaw or a small jigsaw may be used, as well.

Please refer to Figure 3 as the following steps are laid out. In this photo, an oversize circuit board has been used, so that you can see the transparency easier. Notice also that the white peel-off UV shield is still on the circuit board.

Place a mousepad or similar soft material on your tabletop. This is simply used to keep the parts from sliding around on smooth surfaces. It is not necessary, and you do not have to use it.

Place the copper board on the mousepad with its copper side up, and lay the transparency over that. Any text should be readable.

If you have printed out your artwork with the board's edge defined with a black border, it will make it easy for you to align the circuit with the board's edges. Next, place your window glass over the board, and then the transparency.

This simply serves as a method of holding the transparency flat upon the circuit board. It is not necessary to work in a dark room doing this; normal room light will not expose the board that fast. You may wish to turn direct overhead lights off however, which would shine directly on the board. Here again, nothing fancy was used, just an F15 lamp propped up on some blocks to give it three inches of clearance.

Remove the lens from the F15 lamp (to show the bulb) and place it three inches above the glass. Turn on the lamp and allow it to shine for 15-25 minutes. Any time within this range works well. The pre-sensitized board will also have developing times listed with the board. Common sunlight may even be used.

If all is ready and you are prepared to develop the board, peel off the white sticky paper, and again place the board on the mousepad, copper side up, transparency, glass, and all of this underneath your fluorescent lamp. ***Note***: Be sure your transparency is aligned correctly; any text will be readable.

Illuminate the board for 15-25

minutes. At this point, you may be able to see very faint traces upon the board. Some people can see the traces, other people may not. Do not worry, they are there. You may refer to Figure 4 to see the completed set-up. Note in this photo the white UV shield is still in place.

For people making two-sided boards, you may tape your transparency to one side of the copper, develop it, and then flip it over and tape your second transparency to the other side of the board. Develop the second side as you did the first. You, of course, will need to buy double-sided boards.

Step 3: Develop the board. *For safety reasons, please wear safety glasses and plastic gloves at this point.* The developer is not highly caustic, but it is better to be safe. The developer will give mixing instructions; these were followed exactly. My brand developer called for a mixture of nine parts room temperature water to one part developer.

Mix this in a small plastic container (a Cool Whip bowl, for example) and soak the copper board in this solution until all of the developer is removed from the board. You must continuously agitate the container until all copper is showing. You will see it begin to wash away and the copper will show.

When it is finished and all copper is showing clearly, you may rinse the board under cold water. The traces should now be visible on the board. You may reuse this developer many times by storing it in a glass jar. This developing should take around 5-10 minutes. Figure 5 shows the board in the small container, covered with developer.

Step 4: Etch the board. To begin etching the board, again *please wear safety glasses and plastic gloves.* Pour the acid slowly into the small container until it will just cover your circuit board. You do not need a lot of acid to etch the board. To speed up the process of etching, heat is commonly used to warm the acid as it etches the board. There have been many excellent designs in *Nuts & Volts* for heated etching tanks. For people who only make a few boards per year, use the cheap and simple method as I do.

Simply place the small container into a larger container filled with hot tap water. The tank of hot water will warm up the acid quickly and speed up the process of etching. Constant agitation is recommended for etching your board. A small pair of vise grips clamped on the side of the small container may be used to hold the container.

Shake the small container gently to keep the acid moving. Fast shaking is not necessary, just a slow, gentle rocking of the container is all that's needed. Black oily liquid will begin to appear on the surface of the board, then this oily fluid will wash away, and the board begins to etch. You will see that the copper will be removed from the outside and work inwards. The last few drops of copper will be in the center.

Be sure you continue etching until those last few drops of copper are removed. For my 3" x 4" boards, this took exactly 11 minutes. This process is shown in Figure 6. The hot tap water around the small container needs only to be deep enough to warm up the smaller acid etching container.

You may now rinse the board under water. The acid can be reused many times. Again, store it in a glass container.

Step 5: Drill the board. Of all the steps, drilling your board can end up being the most difficult for some people, simply because the holes are so tiny. Please remember to always wear safety glasses while using power machinery. If you can borrow a friend's drill press, this will make the job much easier. Cheap X-Y vises on the drill press will really make things easier. My drill press has a $35.00 X-Y vise, seen in Figure 7. The vise is very useful for multiple inline holes. Clamp the board in the drill press, set it to as high a speed as possible, and drill the holes.

Using the controllable vise, you can go right down a line of circuit pads and drill them all easily. If you do not have a drill press, many people use a small Dremel style Moto-Tool to drill them by hand.

Drill about 25 holes, and take a break for a few minutes to rest your eyesight. The circuit boards drill easily, not a lot of pressure is needed, and if you use a new drill bit, it should not be too hard. Some people use a hand-powered drill, similar to the eggbeater style drills.

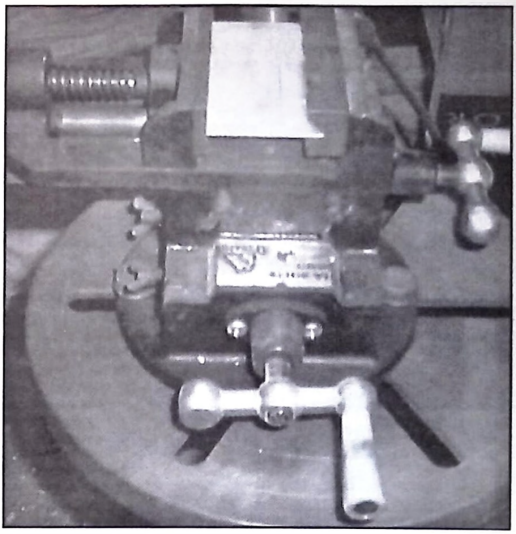


FIGURE 7

Step 6: Soldering. When soldering small traces and pads, use a low-wattage iron, and .025 very fine solder. A magnifying glass always comes in handy, and provides plenty of visibility for soldering tiny items.

For people with double-sided boards, small clipped wires from resistor legs work nicely for the "VIA" through-holes.

The key to making printed circuit boards is to do it yourself. Do not be afraid to waste a few boards learning the process. PC boards are fairly cheap, around $3-$5. This is not a highly expensive investment if you make a mistake. The developer and acid may be reused many times, so you will not waste the chemicals. The first board I made came out very good, except for a trace not connected in my artwork. If you follow the steps outlined, you should not have any difficulties.

If anyone does have problems or wishes to discuss the process further, you may email me at Admin@MntnWeb.Com. I will be happy to offer advice. **NV**

Parts List

The parts necessary to complete a circuit board are as follows. They may all be purchased from Web-Tronics if not available locally to you. I have no affiliation with this company, it is intended only to point out an online source of parts.

1) Pre-sensitized positive (+) acting circuit boards. Single- or double-sided. 4" x 6" (PP101).
2) Positive type developer concentrate 17 oz. size (418-500ML).
3) PC Board Ferric Chloride (the acid) 35 oz. (415-1L).
4) F15 watt fluorescent light. I used an under desk mounted lamp. UV style is not necessary.
5) Transparency that is compatible with your printer.
6) Plastic container that will fit the size of circuit board you etch.
7) Larger container that will hold the smaller container. For example, a Cool Whip tub inside a dishpan tub. The second container will be holding hot water only.
8) One sheet of window glass or similar. I used part of a small glass from a picture frame.
9) PC board, drill bits. Buy a few in case you break one. I use #60 and #63 drill bits. If you cannot find these sizes locally, you can order a #60 and #66 size bit from www.UnicornElex.com #32-6120. There is only one bit of each size in the three-piece kit, (the third bit is 1/16" in size). A local tool supply house should have (number) drill bits in stock for you.

If you cannot obtain parts locally, you may order online from Web-Tronics. They also have a complete kit of parts that contains everything necessary to begin your own boards, for $29.95.

1) 3" x 5" M.G. Chemicals pre-sensitized single-sided "PCB"
1) 4" x 6" M.G. Chemicals pre-sensitized single-sided "PCB"
1) 6" x 6" M.G. Chemicals pre-sensitized single-sided "PCB"
1) 418-500ml Developer
Plastic development tray
1) 415-500ml Ferric Chloride
Rubber gloves
2) Foam Brushes
Instruction Sheet
1-800 Technical assistance

Links

1) **Web-Tronics** http://www.web-tronics.com/webtronics/printed-circuit-board-supplies.html
2) **Unicorn** http://www.UnicornElex.com
3) **PhotoPrinter** http://go.to/cd-labeler-gold
4) **LviewPro** http://Lview.com
5) **MntnWeb** http://MntnWeb.Com/Software.htm Copies of PhotoPrinter and LviewPro
6) **ExpressPCB** http://ExpressPCB.Com

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in step 4.

The above directions will leave the saddle on the dovetail of the base. It's impossible at this point, however, to separate the saddle from the base because the press-fit follower nut gets in the way. You can use a drift punch and a hammer to force the follower nut out, but be very sure you want to do this before you attempt it. At the very least, scribe a couple witness marks between the nut and the machine boss on the underside of the saddle so that you can reassemble them with the proper alignment should you wish to do so.

After you've stripped the table, give everything a good cleaning with a solvent such as kerosene. Remove any light rust spots with steel wool. If you are going to hand scrape the mating surfaces of the dovetails, now is the time to do this. Oil all parts during reassembly.

The Small Table

Next is the "small" X-Y table (Enco #201-2826) intended for the Z-axis:

1) Loosen the allen screws and remove the 5/8" nuts to remove the handcranks.

2) Loosen the allen screws to remove the graduated collars. You may need to use two flat-blade screwdrivers to gently pry the collars loose.

3) Remove two allen head screws from the steel bearing plates to allow unscrewing the leadscrews from their respective nuts. The bearing plates are held captive on their respective leadscrew shafts with steel bushings. The bushings themselves are pinned to their shafts with roll pins. If there is excessive lateral play between a bearing plate and its shaft, you will need to use a hammer and a small pin punch to remove the roll pin. This allows the bushing to slide off the leadscrew shaft so you can then shim the gap with a washer of the appropriate thickness. Using a simple $5.00 thickness gauge, I measured about .005" lateral play in my leadscrew bearings; this is acceptable for the time being, so I've left the bushings in place.

4) Loosen the gib screw lock nuts and loosen the corresponding screws. Slide first the table, then the saddle out of their dovetails. Mark which gib goes with which slide and set aside.

5) Unlike the larger X-Y table, the small X-Y table uses cast bronze follower nuts which are easily removed. Simply remove the screws holding the cast bronze follower nuts to the saddle and the base. Be sure to scribe a couple witness marks on each nut so you can get them back in proper alignment on reassembly.

These small Enco tables are inexpensive, apparently in part because they are slapped together without regard for the niceties. For example, when I stripped my table, I noticed quite a few loose metal chips and burrs. Time spent cleaning the chips out and deburring and filing rough edges will pay off in extended wear life, and you'll be less apt to cut yourself when working on your table. Plus it just looks nicer.

I'm outta here

We're leaving the Robot Ranch behind for a few weeks to fly off to Big Sky Country in Montana for a long overdue vacation. Enjoy the summer reading recommendations. Get a start designing robots to build this winter. That's what I'll be doing — after vacation. See you next month. NV

News Bytes

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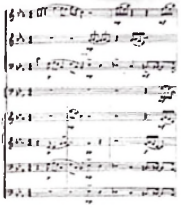
located at 6221 South Maple Avenue, Tempe, AZ 85283, and can be reached at 480-755-4712 or info@cedist.com or www.cedist.com.

MUSICEASE: INTELLIGENT MUSIC NOTATION EDITOR



MusicEase Software has released MusicEase 8.0, a program that lets users quickly create transposable sheet music under Windows 95, 98, NT, 2000, and ME.

MusicEase creates engraver quality sheet music even if you don't know music copyist rules. MusicEase knows things like if the slur should go above or below the notes, and if the tuplet should go between the slur and the notes or outside it.

You see the music on your screen (WYSIWYG) as you edit. Because you need not specify things like slur direction and tuplet location, you can enter music very easily and quickly. For sample printouts, see http://www.musicease.com/samples.html

Artificial intelligence techniques are used to position music notational elements correctly without being told and to create properly transposed music. Things like guitar fret diagrams can be automatically added/removed with just several mouse clicks.

MusicEase works like a word processing program with capabilities like cut, paste, multi-level undo, and print preview so users can learn to use it quickly. MusicEase optionally displays shape notes, automatically converts standard notation to tablature, transposes, retrogrades/inverts blocks, imports MIDI files and scanned music, scales to different sizes, and will automatically cast off (determine optimal system breaks), and justify.

Integrity Music has chosen MusicEase as the driver of the transposable sheet music feature included in its Worship Software.

MusicEase costs $79.95 (standard version) and $199.95 (professional version) for a single-user license. For more information, visit http://www.musicease.com where you can download a fully functional, evaluation version. Or contact MusicEase Software, P. O. Box 9219, Grand Junction, CO 81501. Email: pr@musicease.com. Fax: (970) 434-0793.

BURNING A CUSTOM MUSIC CD NOW EASIER THAN BEFORE

Acoustica has released MP3 CD Burner, a full-featured Windows application that makes it easy to turn MP3 music files into music CDs that play on ordinary home and car stereos.

MP3 CD Burner lets you select your MP3 and WAV songs by doing keyword searches, browsing your music folders, and dragging and dropping your favorite songs, or importing your M3U or PLS playlists. With a single click, you can sort the songs by title, album, artist, length, or date. If you're not sure about including a song in your CD compilation, it's easy to play it directly from the program. The handy editor lets you rename tracks, change the order of the songs, and undo/redo all of your changes. MP3 CD Burner knows how long each song is, and warns you if you're trying to include more music than will fit on your CD.

If your MP3 files contain additional information about a song's track number, album name, artist, track length, and website, you can easily copy this text to the clipboard and use it in other programs such as a CD label maker.

MP3 CD Burner includes features that are normally found only in high-end recording software. You can set the volume for each track manually, or have the program normalize all of the tracks so that none of them will be too loud or too soft. MP3 CD Burner automatically detects incomplete songs, and tells you about them before you burn your CD. The program can trim silence from the beginning or end of songs. You can specify the exact amount of silence to leave between tracks. You can even create segues between tracks by fading out and fading in your songs.

Once you have selected your music and decided how much silence or overlap to have between tracks, a single mouse click starts the CD burning process. There's no need to convert MP3 files into WAV files before burning your CD. MP3 CD Burner supports the newest hardware features, including 80-minute CDs and the latest Burn Proof technology. You can test before you burn, and you can make multiple copies of your CD; the program will prompt you for a blank CD when it completes each copy.

MP3 CD Burner costs $16.95 (US), runs under Windows 95/98/Me/NT4/2000, and may be purchased securely online at http://www.cdburner.com/. You can download a free, fully-functional trial version of MP3 CD Burner that will burn three CDs without any restrictions. The program works with ordinary CDR and CDRW drives that support Disc-At-Once (DAO), and a Pentium II or newer computer is recommended. For more information, contact Acoustica, P.O. Box 728, Oakhurst, CA, 93644; Phone: (559) 692-2224; Email: Biz@acoustica.com; Internet: http://www.cdburner.com/.

NEW PRIVACY SOFTWARE PROVIDES PERSONAL PROTECTION FROM ONLINE TRACKERS AND PRYING EYES

Envision Systems, Inc. has announced the release of Privacy Guard 2.0, a program that allows users to delete individual items stored on their computer by various online entities as a result of their Internet surfing activities.

Privacy Guard 2.0 allows web users to surf with confidence. Surfers can keep their online activities private from anyone with access to their computer. It also allows the user to keep online entities from tracking and reporting what he or she does online. What makes Privacy Guard 2.0 unique is

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SPECIAL SECTION

by Gordon West

GOT AMATEUR EXTRA? GET COMMERCIAL GROL!

The GROL commercial license is your ticket for making money in the marine electronics and aviation electronics fields. GROL stands for General Radiotelephone Operator License, and this is the relatively new name for the old first, second, and third class commercial radiotelephone operator license.

As an Extra class amateur radio operator, you have already studied about 70 percent of the present GROL technical questions; and if you were an Extra class operator who took and passed the 20 wpm code test prior to April 15, 2000, you also received 20 wpm code credit to satisfy the Morse Code requirements for the second and third class commercial radiotelegraph operator's certificate.

In 1984, the Federal Communications Commission (FCC) overhauled commercial radiotelephone and radiotelegraph licenses. The first class and second class radiotelephone operator license was discontinued and replaced with a special lifetime General Radiotelephone Operator License, GROL. The third class radiotelephone operator permit, aircraft radiotelegraph endorsement, and the broadcast endorsement were eliminated and not replaced. The commercial marine license turned into the present MROP — Marine Radiotelephone Operator Permit.

To the surprise of everyone who held a commercial license, the FCC announced it would no longer require the "second class ticket" to install, maintain, adjust, and repair land mobile two-way radio equipment. They also eliminated the "first phone" for the repair and adjustment of TV and broadcast radio equipment, too.

However, the FCC, under international law, still requires the GROL present day commercial license to service and adjust Part 87 aviation radios, Part 80 marine radios, and Part 23 international fixed service shortwave stations. The FCC still requires a GROL along with a radar endorsement to service and adjust aviation and marine radar equipment.

Powerful marine coast radio stations need a GROL licensee on duty.

Also, many municipalities, two-way radio service shops, and many telephone companies throughout the United States still require a commercial FCC license as an employment requirement, even though that license may no longer be required to work on private two-way radio systems.

You will need a commercial radio operator license to transmit over the following radio equipment:

- A boat carrying more than six passengers for hire.
- A marine SSB high-frequency station.
- A boat that sails to a foreign port.
- A ship larger than 300 gross tons.
- Certain high-power land marine coast stations.
- Aircraft stations operating on high-frequency SSB.
- Civil Air Patrol stations on other than VHF frequencies.
- Coast and ship stations transmitting radio telegraphy.

You also need a commercial radio operator license to repair and maintain the following:

- A boat two-way radio.
- A boat radar.
- A shore radio station in the marine or aviation service.
- A marine or aeronautical handheld radio.
- Any aircraft radio or aeronautical ground radio station.

You would also need the Global Marine Distress Safety System operator license, and radio maintainer license if you plan to be a radio operator aboard a large passenger or cargo vessel requiring GMDSS certification.

There are now 12 types of commercial radio operator licenses, certificates, permits, or endorsements that are either required by international radio law, or required in private industry. These licenses are granted after passing examinations selected from seven written and four telegraphy examinations on various subjects.

Marine radars require a GROL to make internal adjustments.

GOT EXTRA?

If you have an Extra class license, either the new one after April 15, 2000,

A GROL license is required to make transmitter adjustments on any marine or aircraft radio system.

or the old Extra along with the Advanced license prior to April 15, 2000, you will find that almost 70 percent of the technical questions look almost identical to what was on the old Advanced and Extra class ham written exams, and on the present amateur radio Extra ham test! Let me explain ...

In 1993, the FCC transferred the responsibility for its commercial radio operator license testing program to the Private Radio Bureau — later named the Wireless Telecommunications Bureau. This is the same bureau that handles amateur radio operator examinations.

Recognizing the success of the amateur radio VEC system, the FCC came to believe that a similar mechanism could be implemented in the commercial radio service, as well. The FCC received legislative authority from Congress to delegate the examination of commercial radio operators to private groups.

There are now eight private groups known as Commercial Operator License Examination Managers (COLEMs). The FCC said that they believed, "... A system with multiple entities managing operator examinations will encourage competition between the entities and result in good service, responsiveness, and lower prices to the applicants." The COLEMs were chosen by the FCC's Private Radio Bureau.

One COLEM that you will quickly recognize is headed up by Fred Maia of the amateur radio W5YI Group. He was the first organization to provide amateur radio operator examinations on a national basis, and was one of the first to offer nationwide commercial radio operator testing as well through its National Radio Examiners Division.

30 DAY DILEMMA

The FCC gave the new COLEMs a scant 30 days to come up with "an approved" set of 170 total questions for marine radio law and operating practices, Element 1, of which 24 questions would be on the exam.

But the biggest challenge was to come up with a total of 916 "approved" questions for commercial Element 3, GROL, of which 76 would appear on the test. Also challenging was to come up with 321 questions "approved" to ship radar techniques, commercial Element 8, of which 50 questions would appear on the test.

Yikes, where in a matter of days could we all come up with 900-plus questions for GROL Element 3? These technical questions all needed a background check for authenticity, and the commercial question pool committee needed to pull this off in one big hurry.

So guess where they turned to for a set of "approved" questions and answer? They went to the amateur radio Advanced class Element 4A and Extra class Element 4B "approved" question pools, and pulled hundreds of questions almost verbatim for the commercial GROL Element 3 exam. They also adopted the same amateur radio sub-element topics, beginning with operating procedures, and ending up with antennas and feedlines.

If you have recently or not recently passed your Extra class exam, I will give you but one example of how well prepared you are to take the commercial GROL test.

New Extra question E4B01 ... "What is a frequency standard?"

GROL question 3C1 ... "What is a frequency standard?"

Extra class question E5A05 ... "What is the magnitude of the impedance of a series RLC circuit at resonance?"

Commercial GROL question 3D8 ... "What is the approximate magnitude of the impedance of a series RLC circuit at resonance?"

There are hundreds of commercial test questions worded exactly the same as what was on the old Advanced test and what is now on the present Extra class ham exam. The answers are identical, too — only the A, B, C, D order has been changed around.

Some questions were ever-so-slightly altered when taken out of the amateur radio question pool:

Commercial question 3A5 ... "What is an ascending pass for a low-earth-orbit communications satellite?"

Amateur Extra class question E2A01 ... "What is the direction of an ascending pass for an amateur satellite?"

Even after the April 15, 2000, combining of original Advanced class questions and original Extra class questions into the new Element 4 amateur Extra class test, close to three-quarters of the commercial GROL Element 3 916 question pool comes almost word for word out of the current Element 4 665 question pool.

Commercial Element 1 rules and regulations are straightforward questions and answers, and brain stumpers like what you should do if you hear a Mayday call may quickly be learned over a weekend. Commercial Element 8 radar endorsement questions will require some study and calculations, but they are no more technical or hard to comprehend than what you learned for your amateur Extra class ticket.

The radar questions were professionally pulled together by Roger Boettcher KB0GEN, owner of Aircraft Communications & Electronics Schools in Virginia Beach, VA.

BUT WHY?

Why not obtain a commercial general radiotelephone license with radar endorsement? If you're looking for employment in the marine or aviation electronics field, it is an FCC requirement to have this license, along with radar endorsement.

The GROL license is good for life, too! And more good news — here is no FCC fee for the license, only an exam fee of approximately $25.00 for Element 1, $25.00 for Element 3, and $25.00 for Element 8. Most applicants who are amateur radio operators take all three exams in one sitting.

Old-time hams who have passed the 20 wpm code test will also study commercial written Element 5 and commercial written Element 6 to obtain their second class radiotelegraph operator certificate. These are written exams, and passing the old 20 wpm Element 1C code test gives credit for second class telegraphy Element 1, 16 code groups per minute, and second class telegraph Element 2, 20 wpm plain language.

BIG FCC CERTIFICATE?

When you pass your examinations, your examination team will issue you a proof of passing certificate which is suitable for framing. It looks nice on the wall. What the FCC will send you is a wallet-sized license, but unfortunately, they no longer have any of the big GROL licenses for framing.

However, National Radio Examiners (800-669-9594 or 817-461-6443) offers a major-sized, wall-sized proclamation that calls out your achievements in passing the commercial exams. Call for details — it really looks nice.

So, if you are studying for Extra class, or have already achieved amateur Extra class status, do consider getting a single book and passing your General Radiotelephone Operator License with ship radar endorsement, commercial Elements 1, 3, and 8. This commercial license will last you a lifetime of future employment in aviation and marine electronics. **NV**

SPECIAL SECTION

RESOURCE BOOK: *GROL Plus*, Q & A with explanations for commercial Elements 1, 3, and 8, for the FCC commercial radio GROL license with radar endorsement. Third Printing, January, 2000, 496 pages. $40.00 and autographed by this writer, 2414 College Drive, Costa Mesa, CA 92626.

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its ability to allow the user to view each individual item put on their machine and choose whether or not to delete or keep that item. Privacy Guard 2.0 detects each individual user ID on a specific machine, what operating system and web browser they are using, and provides all the details of their web activities. Depending upon what operating system or web browser the user is running, they will be able to view all files where information is stored. This would include their history, recent locations, cache, cookies, archives, favorites, temporary files, scan disk files, downloaded files, and the "run" option of the start menu. In all cases, the user will have the option to delete an individual item, or delete all the items in that file. In certain cases, the user will be able to open a file, browse a website, and edit the title of a certain item.

Privacy Guard 2.0 performs under Windows 95, 98, NT, and 2000. It works with Internet Explorer 3.0, 4.0, 5.0, 5.5, and the brand new MSN Explorer. It also performs with Netscape Navigator 3.0, 4.0x, 4.72, 4.73, 4.75, and AOL 4.0, 5.0, and 6.0.

Privacy Guard 2.0 is available as a downloadable product with a 21 day free trial period. Purchase price is $34.95. Licensing options are available, and buyout offers are being entertained. For more information, contact John Meyer at Envision Systems, Inc., 14201 Crown Drive, Eden Prairie, MN 55346. Phone 952-949-8663, email johnmeyer@envisionsystemsinc.co

EXTRACT USABLE DATA FROM JUST ABOUT ANYTHING

Guy Software has released ParseRat 2.0, a Windows application that lets you pull all important information out of files and databases, even if you don't know what program originally created the data. You can capture information that was created by obscure or unknown applications, separate or "parse" it into fields, and convert it into a file that can be easily imported into your database, spreadsheet, or other application.

For database, fixed-format, delimited, and page image records, ParseRat shows you the data, and helps you define on-screen where the valuable information lies. Using intuitive point-and-click screens, creating a conversion template takes only a few minutes. ParseRat can convert thousands of records per minute to your new format.

If the data was originally created on a mainframe, ParseRat performs the EBCDIC-to-ASCII conversion instantly. The program also handles

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Use the classifieds, they're cheap and they get great results!

TYPE or PRINT your **ELECTRONICALLY RELATED** ad copy **CLEARLY (not all caps)** on a separate piece of paper. Spell out words when submitting handwritten copy. Calculate the number of words and multiply it by the appropriate rate (see RATE PER WORD section). Include any charges for bold and/or CAPPED words, any artwork costs that would be applicable, and/or costs for boxing your ad (explained below). Choose the appropriate classification for your ad(s) to appear in (see below). If no classification is indicated, it will be placed in Misc. Electronics or wherever we deem most suitable. **Enclose your name, address, phone number, and *Nuts & Volts* account number from your mailing label** (if available) for identification purposes. Include full payment — **CLASSIFIEDS RUN ON A PRE-PAID BASIS ONLY** — and mail your completed order to:

NUTS & VOLTS MAGAZINE
430 Princeland Ct, Corona, CA 92879.

RATE PER WORD

The ad rate for **current PAID subscribers** is **60¢** per word. All others pay **$1.20** per word. There is a **$9.00 minimum** charge per ad per insertion.

WORDS IN BOLD AND/OR ALL CAPS

Words to be set in **bold** or CAPS are each 10¢ extra PER WORD. **BOLD CAPS** are 20¢ extra per word. The first two words of each ad are bold capped at no charge. Indicate bold words by underlining. Words normally written in caps (e.g., IBM) and accepted abbreviations such as VAC or MHz are NOT charged as all cap words. Use a two-letter abbreviation for states.

PHOTOS, DRAWINGS, AND BOXES

A photo or drawing may be run at the top of your classified ad for an additional **$10.00** (1" depth max.) for camera-ready art. No wording is allowed in this area. To **BOX** your ad, include an additional **$50.00** for copy-only ads, or **$75.00** for ads with art or photos. Photos may be emailed to classad@nutsvolts.com.

EMAILING OR FAXING IN AD COPY

You may email or fax in ad copy or changes before the closing date (5:00pm on the **5th**) using MasterCard or Visa. Include credit card expiration date, the name that appears on the card, a daytime phone number, and your *Nuts & Volts* account number. Email ad(s) to classad@nutsvolts.com or fax to 909-371-3052. Ads without credit card information will not be listed as received until payment is received in full. **WE DO NOT CALL, EMAIL, OR FAX BACK VERIFICATION OR QUOTES OF EMAILED AND FAXED-IN ADS.** For verification of emailed or faxed-in ads, please call 909-371-8497.

DEADLINE

Prepaid ads received by 5:00pm on the **closing date (5th of the month)** will appear in the following month's issue. Ads postmarked through the 5th, but received after the closing date, will be placed in the next available issue. No cancellations or changes after the 5th. Cancellations and changes must be submitted in writing.

IMPORTANT INFORMATION

All classified ads are running copy only. No special positioning, centering, dot leaders, extra space, etc. is allowed. All advertising in *Nuts & Volts* is limited to **electronically related items ONLY.** All ads are subject to approval by the publisher. We reserve the right to reject or edit any ad submitted. We do not take ad copy or changes over the phone. We do not bill for classified ads. Repeat ads or ads run in multiple classifications within the same issue are allowed. Paid subscribers may run ads at the 60¢ rate only through their subscription expiration date. **NO REFUNDS.** Credit only. No credit for typesetting errors will be issued unless you *clearly* print or type your ad copy.

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Choose a category for your ad from these classifications.

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Find what you need FAST

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all of the binary, packed, and zoned numeric formats that are traditionally used on mainframe systems.

Thousands of computer programs store data in their own proprietary formats. ParseRat lets you work with these files by stripping away their header information, and giving you access to the fixed-format records that lie beneath. Mystery files are converted into simple import files for your spreadsheet or database. Even if you can't unscramble the master files of an application, you can usually extract the data you need from reports "printed" to a file.

ParseRat can even handle emails and other variable length records with variable length fields. For example, you can grab screens full of data and tell ParseRat that you want to capture the fields that follow on-screen tags such as "person" and "city." It can even parse data from the Windows clipboard.

ParseRat has special logic to process names and addresses. The program's parser can intelligently look for multi-word first and last names, as well as complex combinations of prefixes and suffixes. ParseRat's genderizer has tables of 10,000 male and female names so you can accurately put "Mr." and "Ms." into your salutations. The program can break down addresses into their individual elements, and recombine them into the format that your database system requires. Similarly, ParseRat can convert numeric fields and dates into the format that you need.

With its XML support, ParseRat makes it easy to pull data out of files created in today's hottest file format, or export data into it. The program can generate Soundex codes, and eliminate duplicate records based upon actual data or sound-alike data. With its command-line interface, you can even run ParseRat from within other programs.

ParseRat 2.0 runs under Windows 95/98/Me/NT4/2000, costs $49.95 (US), and may be purchased securely online at http://www.guysoftware.com/. For more information, contact Guy Software, 1752 Duchess Avenue, West Vancouver, British Columbia V7V 1P9 Canada. Phone: (604) 926-1370 Fax: (604) 926-1346 Internet: http://www.guysoftware.com/Email: ed@guysoftware.com. **NV**

Build The TWEAK-O!

by Steve Daniels

1. The finished pedal. It's not too hard to get a very professional appearance!

Not every musician wants to learn to build equipment, but to those who do, the reward of "owning their own tone" offers tremendous satisfaction.

This article is directed to guitar players who have considered building their own stomp boxes, but who need an "entry-level" project appropriate for a complete newcomer to electronics. I looked for a circuit that would:

- Be simple, using no more than one transistor.
- Still create sounds useful to a gigging musician.
- Use only very readily-available components.
- Require only basic hand tools and no test equipment to build.

The Tweak-O is an overdrive pedal with adjustable clipping. The circuit was developed by Joe Davisson, who is a well-known contributor to the guitar effects message boards. It is similar in design to a number of other one-transistor boost/distortion pedals, but it offers remarkably good sound for something so simple.

I will start with some technical background and give you references for learning things I don't cover fully here – like reading schematics and soldering. Then I'll walk you through building the Tweak-O and getting it working. This won't be a toy; the construction methods will be the same as those used in many commercial and boutique pedals.

All of the components are available either from RadioShack or by mail order, or you can get a complete kit from the source in the Parts List.

I expect that some experienced hobbyists will be disappointed that I did not include features like pull-down resistors, an in-use LED, and a DC power jack. Also, I know that many, many modifications and additions to the Tweak-O are possible. Realize that I had to make some design choices, and that one of those was to keep the component count – and so the complexity – to an absolute minimum.

Anyone who builds the Tweak-O successfully will have learned enough to tackle a more complicated pedal, and maybe even enough to modify the Tweak-O to taste.

Tools And Materials

You'll need a 25- to 35-watt soldering iron, rosin-core solder, and cleaning sponge and some other basics:

- Small screwdriver(s)
- Small diagonal pliers and cutters
- Small locking-grip ("vise-grip") plier
- X-acto™ knife
- Self-locking tweezers or other "third hand"
- Small alligator clip
- Colored pencil or highlighter felt-tip marker
- Electric drill and twist drills from 1/16" to 1/4" (a Dremel tool is also very helpful)
- Tapered reamer
- Some small round and flat files
- A pointed steel "pick" or scratch awl
- De-soldering braid (RadioShack p/n 64-2090B)
- Mixing cup, stirrer, and brush for epoxy sealer

For finishing the case, you'll need:

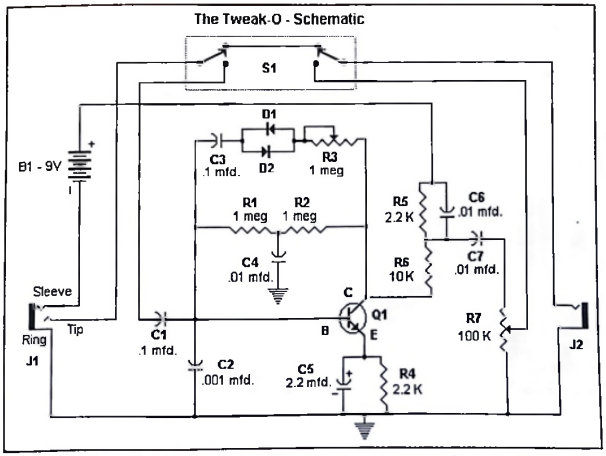
- 220-grit and 400-grit (or finer) carborundum paper
- Acetone, denatured alcohol
- Spray primer and enamel
- Clear adhesive label stock
- Quick-setting epoxy glue
- Epoxy sealer

Reading A Schematic

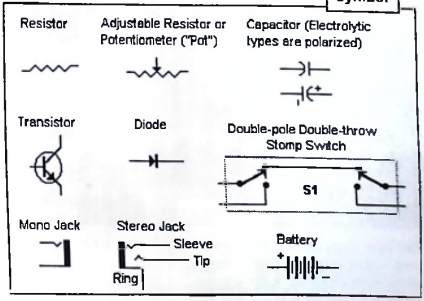
You don't have to understand or be able to interpret a schematic in order to build the Tweak-O. But it's a good idea to at least take a look, so I'll give you a running start on the learning curve. The references at the end of this article will take you further. See Figure 2.

A schematic may look like an abstract painting, but well-drawn ones have a consistent logic once you learn what the symbols mean. Every symbol represents a component and the symbols are internationally recognized; the symbol for a resistor is the same in the US as it is in the smallest factory in the Far East. The straight lines represent component leads or connections

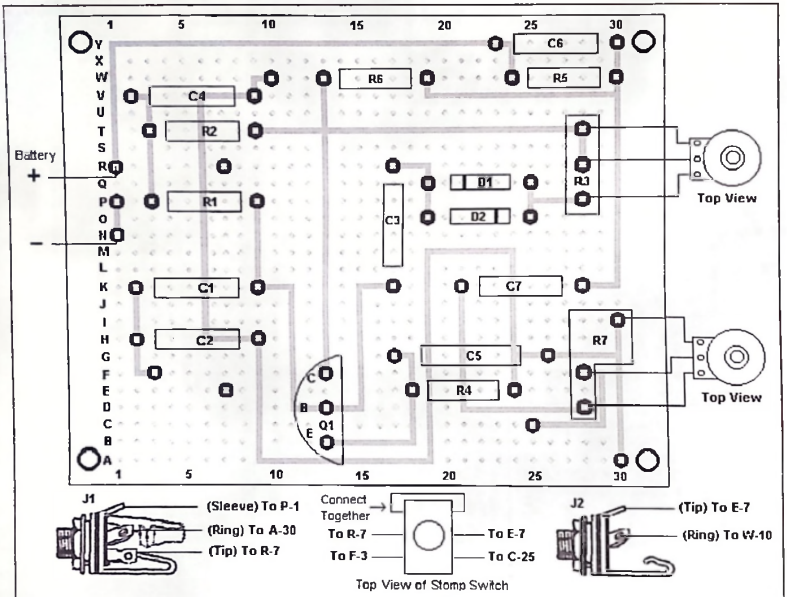
Ground Symbol



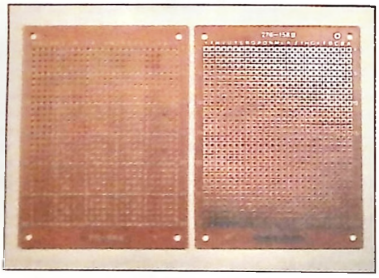
2. The schematic of the Tweak-O. It's a one-transistor amplifier with diodes that "clip" the guitar signal.



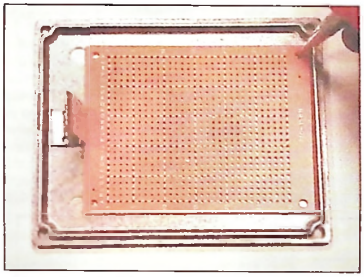
3. Schematic symbols.



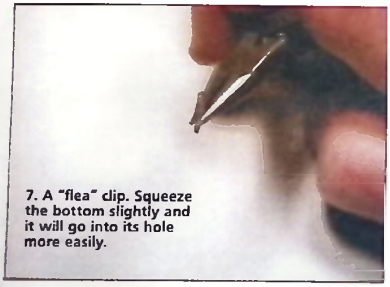
4. The layout of the Tweak-O board. The letter-number coordinates refer to the perfboard.



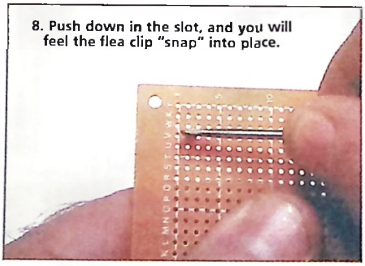
5. This RadioShack perfboard is indexed so that points in the circuit can be located easily.



6. The board will mount on threaded studs later. Using a pick or awl, scratch the locations for the studs and the battery clip now.



7. A "flea" clip. Squeeze the bottom slightly and it will go into its hole more easily.



8. Push down in the slot, and you will feel the flea clip "snap" into place.

between components, and the heavy dots indicate where component leads join. Only a few component types are used in the Tweak-O. See Figure 3.

The symbol means "ground" or "common." In this case, ground does not mean a connection to the earth itself; it just means that all the points that show this symbol are connected together. Ground is the point from which all voltages are measured.

Every component type has a designating letter, and individual components are numbered for identification; so, resistors are always "R" and capacitors are always "C," for example. Transistors are always "Q." This system makes it easy to locate, for example, "the junction of the emitter ("E") of Q1, the positive side of C5, and R4."

A schematic shows the logical relationships between components, but it doesn't necessarily show physical relationships — where components are mounted in relation to each other. Once a circuit has been proven to work, a designer's first job is to translate the schematic to a suitable layout on a chassis or circuit board. I have done this and the layout in Figure 4 is the drawing from which we will build.

This layout drawing is about 1-1/2 times actual size. Because I'm teaching, I made it larger than I usually would. Also, I was more than usually generous with space between components. But in all other respects, it represents the way a professional might wire a prototype. The drawing shows outline views of the components in heavy lines, and it shows how they connect to each other in gray lines.

The connecting lines are in "X-Ray" view; that's to say that you are seeing directly the components on the top of a circuit board, and seeing the connecting wires through the board. If this isn't clear right now, it will be when we start to wire.

At this point, you might want to start getting familiar with the components you've bought by matching and looking at them against both the schematic symbols and the layout drawing. The references at the end will give you more information about recognizing components and reading values and color codes. You can also email me at smallbearelec@ix.netcom.com with specific questions.

Construction Methods — Using Perfboard

Perforated circuit board — or perfboard as it is commonly called — is a convenient material for building a hand-wired prototype.

Components are mounted on push-in terminals that are inserted through the holes in the board. Connections are made on the opposite side with short lengths of bare wire. (More experienced hobbyists will probably prefer to insert component leads directly into the board, but I recommend push-in terminals for first-time builders.)

Perfboard can be purchased as a large sheet and cut down, or in a variety of pre-cut sizes. RadioShack offers a piece of perfboard — p/n 276-1588 — with copper-clad, predrilled mounting holes, that is a very good size for building stomp boxes.

Both sides of the board are indexed. If you look at Figure 5, you'll see that every one of the 750 pre-punched holes in the board can be identified by a letter-and-number coordinate. I use the indexing on the board to refer to the position of every terminal in the layout drawing. You can locate the components and do the wiring "by the numbers." Are you ready to build? Let's go!

One thing to do before putting terminals in the board is to use it as a template to mark on the lid of the case the places where we will later glue mounting studs and the battery clip. Figure 6 shows how to do this with a scribe or scratch-awl.

Begin by inserting the push-in terminals (old-timers knew these as "flea clips") for capacitor C4 at locations V-2 and V-9. I have found that the terminals go in easily if you squeeze the bottom just a little with diagonal pliers (Figure 7) and then push down firmly but gently in the top slot with the edge of a small screwdriver (Figure 8). Squeeze the top flanges together a little bit so that a wire inserted between them will be held gently in place.

Cut the leads of the capacitor down to 5/16" long, and bend them to right angles. The bend starts about 1/16" from the body of the part. Insert the capacitor between the terminals, and solder in between the flanges. The result is shown in Figure 9.

Now use the same general method to mount all of the other components. The leads of the resistors and the diodes don't have to be bent; just cut them off. The order in which I mounted the components was: C4, R2, R1, C1, C2, R6, C3, Q1, C6, R5, D1, D2, C7, C5, and R4.

A few suggestions for this part of the job:

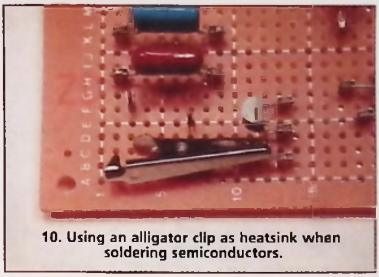
* Insert the terminals with their flanges facing toward each other, and leave five holes between terminals for the resistors and six for the capacitors (eight for C5). As you can see in Figure 17, this made for a clean, but comfortable layout.

* If you make a mistake and need to reposition a terminal, push it out from the bottom of the board with the blunt end of a plastic or metal rod. Then re-insert it.

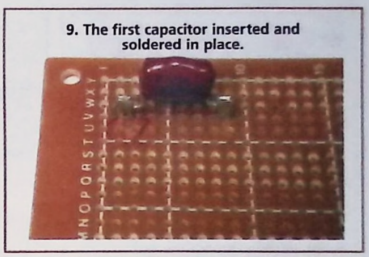
* Save the pieces of wire that you cut off from the components. We'll make use of these later when wiring on the opposite side of the board.

* Modern transistors and diodes are reasonably tolerant of soldering heat, but it still pays to be careful. As shown in Figure 10, use an alligator clip as a heatsink on each lead of these devices.

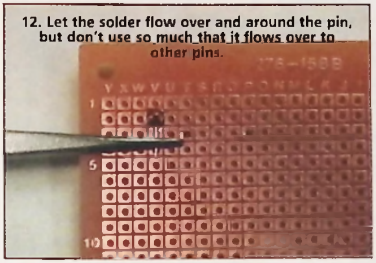
* Be careful to orient correctly the transistor, the diodes, and the electrolytic capacitor C5. If you need to, refer to the photo of the finished board, Figure 17.



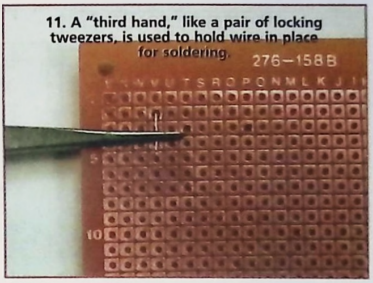
10. Using an alligator clip as heatsink when soldering semiconductors.



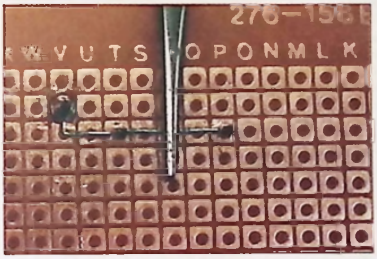
9. The first capacitor inserted and soldered in place.



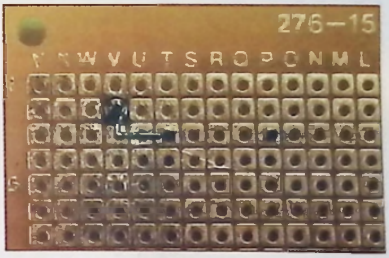
12. Let the solder flow over and around the pin, but don't use so much that it flows over to other pins.



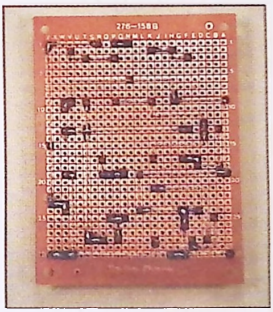
11. A "third hand," like a pair of locking tweezers, is used to hold wire in place for soldering.



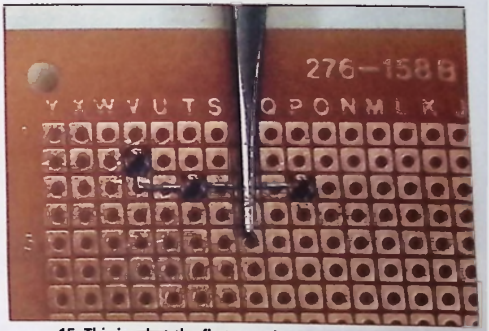
14. Lay the next segment, just as though you were laying pipe!



13. Make the bend so that the free end just butts against the terminal to which it is going. Don't wrap around!



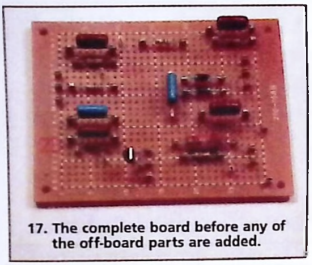
16. Here's the whole solder side of the board. In some cases, it is acceptable to let solder flow between pads to create a "bridge." The list of connections indicates where you can do this.



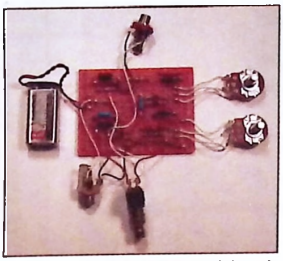
15. This is what the first complete segment looks like when it's done.

Once all of the components are mounted, insert the pins for the off-board connections: R-1, P-1, N-1, F-3, R-7, E-7, W-10, C-25, T-28, R-28, P-28, F-28, D-28, I-30, and A-30.

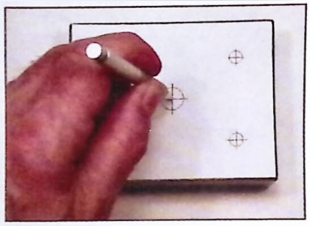
Now you can wire the connections on the "solder side" of the board. I began by connecting one side of capacitor C4 to one side of resistor R2 and one side of resistor R1. In the layout drawing, these are points V-2, T-3, and P-3.



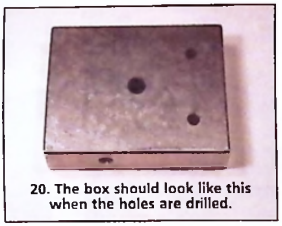
17. The complete board before any of the off-board parts are added.



18. The board with all of the off-board connections.



19. Use drilling templates, and use an awl or pick to create indents where the holes will be drilled.



20. The box should look like this when the holes are drilled.

21. I use a dental pick to position each decal.

This is the point at which you have to start thinking like a plumber. Cut a piece of wire just over two pads long to connect V-2 to T-3. Butt one end against pin V-2 and hold it down with the locking tweezers. Solder so that the pad is filled. See Figure 11 and Figure 12.

Now use diagonal pliers to bend the free end toward point T-3. As though you were bending pipe, allow for the radius of the curve in the wire when you bend it. See Figure 13. Now cut a length of wire just over three pads long to go from T-3 to P-3, and hold it in place. See Figure 14. Solder at T-3 and P-3, and the result looks like Figure 15.

This is the basic technique. In most cases, you should use as little solder as needed to fill the pad where you are soldering. However, to connect two or more adjacent pads, it is acceptable to flow solder between them to create a "solder bridge." I have noted in the list of connections those places where you can do this. Each time you solder a connection, mark it off in the layout drawing using a colored pencil or highlighter.

In general, don't wrap a connecting wire around a terminal. It isn't just unnecessary; it wastes space. In the places where the layout is tight, this may cause a short. Be careful to cut the terminating end to such length as the wire just butts against the terminal to which it is going. If you make a mistake, mop the solder from the joint(s) using the de-soldering braid, remove wire or components as necessary, and re-think before you solder again.

Here is a list of connections, with some notes where I think they may be helpful:

P-1 to N-1 Connect these with a solder bridge.

K-2 to H-2 to F-3

R-1 to Y-23 to W-24 I did this in sections rather than with a bend. Cut a piece that will go from R-1 to Y-1 and solder at R-1. Cut and fit the piece from Y-1 to Y-23 and solder at Y-1. Then solder bridge from W-24 to Y-23.

W-10 to V-9 to H-9 This starts the ground line. Lay and bend the segment from V-9 to H-9 (run it in column 6) and solder at V-9. Apply solder at N-6 to hold it in place. I will refer to this procedure as "tacking" a connection. Solder bridge from V-9 to W-10.

H-9 to E-24 Continues the ground line. Route as shown in the layout and tack it at the bends: A-9, A-19, M-19, M-24. You can use individual segments or bend wire as you like.

T-9 to T-28 to R-28 Solder bridge from T-28 to R-28.

F-13 to W-13 Tack to the wire crossing at T-13.

P-9 to K-9 to D-13 Cut a wire nine pads long and solder it at P-9. Bend it to run in column 11 and butt to K-9. Lay the wire from K-9 to D-13 and solder at K-9.

D-13 to K-17 Run in column 15.

B-13 to E-18 to G-17 Solder bridge E-18 to G-17.

R-17 to Q-19 to O-19 Q-19 to O-19 is a solder bridge.

O-25 to Q-25 to P-28 Cut a lead to fit in row P between P-28 and the middle of the path from O-25 to Q-25. Solder at P-28 and solder bridge O-25 to Q-25.

K-28 to W-30 to W-19 to Y-30 Lay the wire from K-28 to W-30 and solder at K-28. Lay a wire from V-30 to V-19. Solder bridge from Y-30 to V-30. Solder bridge from W-19 to V-19.

I-30 to A-30

G-24 to G-26 to G-30 Cut a wire 3-1/4 pads long and lay it from G-30 to G-26. Tack it to the wire crossing G-30. Solder bridge from G-26 to G-24.

C-25 to F-28

D-28 to K-21

The finished solder side of the board is shown in Figure 16.

When you are done with the connections between components, make the connections that go to the off-board parts – the pots, jacks, battery, and switch. Refer to the layout drawing and Figure 18, and be sure to orient the parts as shown in the layout drawing when you are figuring out which lead goes where.

The connections to the input jack, in particular, are often confusing to beginners. The one in the photograph is a Switchcraft #12B, which comes with the kit; other brands may not look quite the same mechanically, so make sure that you know which contact is tip, ring, and sleeve. Mark off each connection in the layout drawing as you finish it.

When the off-board connections are done, the board is finished and ready for testing.

Fire It Up!

Attach the snap to a nine-volt battery, plug your amp into J2 and a guitar into J1. Like other modern effects, the Tweak-O turns on power by switching the battery through the sleeve of the input jack. Turn both controls to mid-range. If you don't hear some buzzy distortion, push S1. If you have done everything right, you'll notice the boost clearly. Try increasing the distortion. The volume goes down naturally with the clipping level in this kind of circuit, but there's enough reserve in the level control to compensate as needed. Got the effect? Congratulations!

Troubleshooting

If you are having trouble, trust me, it IS a wiring error. Don't panic, and don't give up. Everyone who has ever built a pedal has been through this, and the cure is the same. Put down your tools, go take a shower (since we know you haven't taken one for several days because you just had to finish this thing), and patiently go over all your connections from the beginning; you will find the mistake. If you need to talk out problems, email me or post on the Stompbox Forum listed in the References.

Tooling The Case

Once you have a working effect, you get to build a home for it. This is actually harder than building the board, but it's the most fun once you learn the techniques

Where To Find Help And Information

For articles on construction and design techniques that apply generally to building electronic equipment, the magazine in your hands is super! If you don't subscribe to *Nuts & Volts* yet, you should.

Then there are the on-line resources. One of the best effects web sites in the on-line world is named, appropriately, the Guitar Effects-Oriented Web Site, or GEO to us pedal-philes. The guy who runs it, R. G. Keen, is a most knowledgeable engineer who has turned his talent to developing both clones of classic effects and creative ways to generate new ones. When I chose to return to the hobby of my teenage years, Keen was generous in answering questions and helping me to get the mental gears cranking again. WWW.GEOFEX.COM is one amazing resource.

For a place to exchange ideas with other interested people, check out Aron Nelson's Stompbox Forum (www.ampage.org and follow the link). While it's a beginner-friendly place, a number of very knowledgeable people regularly post and answer questions there. Aron also has great sections on his site that deal with beginner issues – components, tools and techniques, as well as one of the best archives of effects schematics in the on-line world.

And, of course, yours truly. I picked up hobby electronics again after many years of making my living as a technical writer. The rise of on-line commerce has allowed me to marry business and pleasure, and I now operate a "general store" for stomp box parts. My web site also has some original and vintage pedal designs, and a Repair Tool section. The "cave" of Small Bear Electronics is at http://www.pistoncom.com/~smallbear/elec.

involved.

The most common type of enclosure for effects is a cast aluminum box with a screw-on lid. Many sizes of these are available commercially, but the most practical for many effects is made by Hammond, their model 1590-BB. Eddystone – Hammond's European subsidiary – makes one that is almost identical. These boxes are available from many distributors here and abroad, or as part of the kit.

The most important step in tooling your box is locating the holes for the switch, controls, and jacks such that these components will fit in and around the board. It's very frustrating to be putting an effect together and finding that the stomp switch is trying to occupy the same physical space as a capacitor. Fortunately for you, I've done all of the planning. If you use the specified box and the drilling templates that are available on my web site, you'll find that the Tweak-O goes together just like a jigsaw puzzle. Take a look at Figure 19.

With a good, sharp scissor, cut out the cover template. Attach a couple of pieces of thin, double-sided tape to the box, and carefully center the template to the cover. Now use a scribe or scratch-awl to put a small dent at the center mark of the hole for the stomp switch. Drill a pilot hole with a 1/8" bit, enlarge the hole with a 1/4" bit, and then use a tapered reamer to slowly bring the hole to its final size. Follow the same procedure for the other holes in the cover, and then the holes on the sides. De-burr all of the holes with a small, round file. Remove all of the templates and tape, and the result is shown in Figure 20.

Painting

There are many "best" methods for preparing a metal surface and putting down a baked-enamel finish. But the ones I've seen all agree on at least one point: the surface to be painted has to be operating room clean; no oxidation, no grease, no dirt. So, using carborundum paper, thoroughly sand the surface to a uniform smoothness, and then clean up every bit of residue with a rag wetted with acetone. You'll know when the surface is clean when a fresh rag comes away with no more grit on it. **(CAUTION: Acetone is extremely flammable and its vapors are toxic. Read and follow the precautions on the can!)**

Once the surface is clean, don't touch it! The oil from your fingers is enough to keep paint from adhering. When moving the pieces, pick them up from the underside.

Painting a stomp box is like painting a car. I put down a sandable, spray auto-body primer and then followed with two coats of enamel. Follow the manufacturer's directions respecting temp and humidity, spraying distance, and drying times between coats. One tip that I saw on a message board that seems to help prevent bubbles in the finish: Before you spray, run a hair dryer set on high over the surface for a minute or so.

Like a car body, your box has to be baked to boil out the solvents in the paint and leave a hard finish. The next time you see a yard sale, find a toaster-oven that has a temperature setting; someone is always getting rid of one of these. Bake the pieces of the box at 150 degrees for one hour and then let them come down to room temp.

Decorating

Experienced pedal builders use a made-for-the-purpose decal stock that can be bought from mail-order sources. The method I suggest here isn't as sophisticated, but it is easier technically and uses materials more likely to be found locally.

Using an ordinary ink-jet printer, I printed the designs you see on the model on Avery #8665 clear adhesive label stock. Set your printer for the greatest possible density, and the resulting images and lettering will show up well on any light-colored paint. My own tastes in designs are a little conservative, but feel free to let your own imagination run riot.

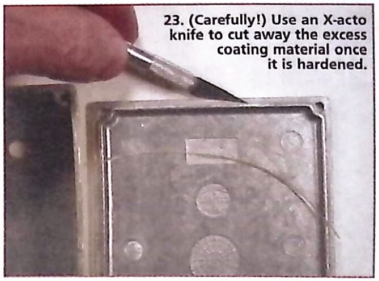
Use a sharp scissor to cut out your decals and, as shown in Figure 21, use a flatted dental pick to position them before smoothing them down. I put the knobs in position just to make sure that I was leaving enough room for them to clear the decals.

Put Down A Top Coat

See Figure 22. Good hardware stores sell a two-part epoxy sealer that dries clear and hard. The directions that come with the bottles give a lot of useful how-to information, so read thoroughly before you do anything you regret! It also isn't unreasonable to try a test run on something you can throw away.

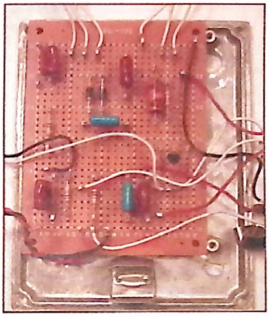
When you are ready, prop the box on a support as shown, mix (thoroughly!) 1-1/2 ounces of the sealer, and pour and brush it on. I coated the lid of the box separately for photographic reasons, but you can do both pieces at the same time. The ounce-and-a-half of material is enough.

When the epoxy has fully cured, use an X-acto knife to slice away the coating on the edges of the box and from the insides of the holes as shown in Figure 23. Be sure that the halves of the box fit together cleanly.

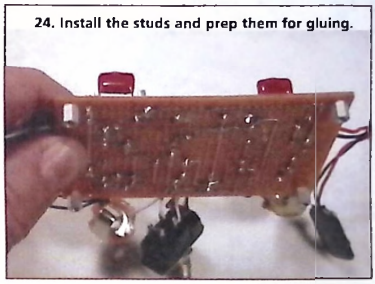


23. (Carefully!) Use an X-acto knife to cut away the excess coating material once it is hardened.

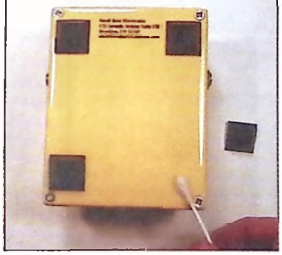
22. An epoxy sealer gives a clear, hard finish that will resist beer and soda spills.



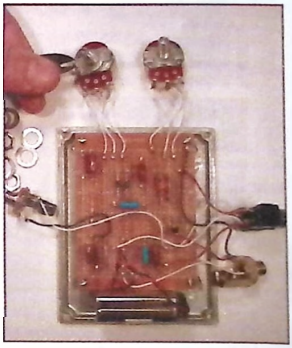
25. Once the epoxy has set, add a little more around each stud.



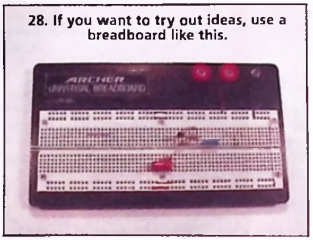
24. Install the studs and prep them for gluing.



27. To stick well, rubber feet prefer a clean, smooth surface to attach to.



26. Cut the locating tabs off the potentiometers and get ready to put the pedal together.



28. If you want to try out ideas, use a breadboard like this.

Putting It All Together

Remember that the first thing you did was mark the locations on the lid where the board and the battery clip would be secured? Sand each of these points shiny, and clean up with acetone. Be very careful not to let any of the solvent get on the painted outer surface. With a 4-40 x 1/4" screw, secure a threaded spacer in each mounting hole of the board. See Figure 24. Sand or wire-brush the bottom and sides of each spacer and clean up with acetone, and do the same to the bottom and top surfaces of the battery clip. If you have it, a Dremel tool with a small wire brush is excellent for this job. Mix some quick-setting epoxy, apply a small amount to the bottom of each spacer, and carefully set the board in place on the lid. Hold it in place till the epoxy sets. Mix some more epoxy and cement the battery clip in place. When the bonds are solid, remove the screws and add additional glue around each spacer. See Figure 25.

Assemble the pedal. Remove the mounting hardware from the controls and jacks, and cut the locating tabs off from the potentiometers (Figure 26). Install a battery, and fit the pots, jacks, and switch in place. Screw on the mounting hardware finger-tight, and then tighten the nuts with a locking-grip plier or socket wrench.

Now, carefully, fit the case together. You'll have to push the connecting wires around a little to do this. Secure the screws, and press the rubber feet onto the bottom. To get the best adhesion, clean the area where you put these down with a little alcohol (Figure 27).

Add knobs to the controls, and try out your pedal. If it works, CONGRATULATIONS! If you have problems at this point, it's almost always because something is shorting inside or a wire has broken. Time to open up again and look for the problem. Sometimes you have to find the problem by connecting your guitar and amp to the effect with the case open and listening to the amp while you close the case carefully. In this way, you may see or feel what is causing the sound to change or go away. In my prototype, I had to rotate the output jack so that the flange that contacts the tip of the guitar plug could bend to the side rather than up (and short to the case).

It's Great, But I'd Like It To Sound More ...

There are many changes that you can try, but it's best to do this kind of experimenting on a prototype breadboard. Figure 28 shows one that is available at your local RadioShack for about $20.00. Buy another set of components (costs beans because you don't need the box or the switch) and you can fiddle to your heart's content. Try different capacitor values and different diodes; in particular, using germanium diodes instead of silicons produces a different effect. Another thing to try is removing the diode loop from the circuit entirely and seeing how you like the Tweak-O as a flat boost. Yes, you can put a simple switch in the diode loop so that you can switch between flat boost and distortion. A footswitch for this? Certainly, but you might want to plan a new layout – minus flea clips – that leaves enough room for a second stomp switch. Are you getting the itch to try another pedal? Careful, they're like peanuts!

I hope you enjoy building the Tweak-O, and I welcome questions or comments at smallbearelec@ix.netcom.com.
NV

Parts List/Bill Of Materials For The Tweak-O

		RadioShack	Mouser
Fixed resistors are 1/4 watt, 5% tolerance, carbon film or composition			
R1, R2 - 1 megohm	1	271-1356	291-1M
R3 - 500K linear taper potentiometer	1	900-7912	31VA601
R4, R5 - 2.2K	2	271-1325	291-2.2K
R6 - 10K	1	271-1335	291-10K
R7 - 100K audio taper potentiometer	1	71-1722	31VJ501
Capacitors			
C1, C3 - .1 mfd. poly-film or mylar	2	272-1069	146-250V.1K
C2 - .001 mfd. poly-film or mylar	1	900-2241	1432-2102
C4, C6, C7 - .01 mfd. poly-film or mylar	2	272-1065	146-250V.01K
C5 - 2.2 mfd. 16-volt axial electrolytic	1		140-XAL16V2.2
D1, D2 - 1N4001 silicon diode	2	276-1101	625-1N4001
Q1 - 2N3904 or similar NPN silicon transistor	1	276-1617	625-2N3904
J1 - Stereo Jack, Switchcraft #12B or similar	1		274-312 502-12B
J2 - Mono Jack, Switchcraft #11 or similar	1		274-252 502-11
S1	1	DPDT alternate-action switch, Carling 316-PP or similar (available from Small Bear Electronics)	
B1 - Nine-volt transistor radio battery	1		
	1	Cast-aluminum box, Hammond 1590BB or similar	546-159
	OBB		
	1	Perforated Phenolic Board	276-158B
	50	Push-in terminals	574-T42-1/C
	2	Knobs for 1/4" shaft	74-415 5164-1510
	4	4-40 x 1/4" threaded spacers	910-3018 534-1891
	4	4-40 x 1/4" screws	64-3011 5721-440-1/4
	1	Nine-volt battery snap	270-325 123-6008
	1	Nine-volt battery clip	270-326 534-080
	4	Rubber Feet	64-2342 517-SJ-5023
		Tinned bare connecting wire #22 or #24 stranded hook-up wire	278-1341 602-299/1-100
			278-1224 602-3050-100-xx

The Carling stomp switch is available for $9.00 plus $.50 postage in the US. A complete kit containing all of the above except for the battery is available for $39.95 plus $4.00 shipping in the US. Checks or money orders to: **Small Bear Electronics**, 123 Seventh Avenue #156, Brooklyn, NY 11215. Or PayPal to smallbearelec @ix.netcom.com. Rates for overseas shipping and prices of individual parts can be found on-line at **http://home.netcom.com/~smallbearelec**.

New Product News

ETHER6 CONTROLLER

JK microsystems, Inc., unveils the new Ether6 controller. Ideal for applications requiring multiple serial ports, Ethernet connectivity and control, the Ether6 packs a DOS-based computer, 10BASE-T, six serial ports, optional 10BASE-2, and many other features all into a rugged, aluminum enclosure.

Based on the powerful Intel 386Ex processor, the Ether6 builds on JK microsystems solid foundation of robust embedded microcomputers with Ethernet capability. PC-compatible serial ports with unique interrupts and FIFO's increase data throughput. Onboard NE2000-compatible Ethernet connects directly to existing networks. The optional 10BASE-2 Ethernet interface allows the Ether6 to integrate seamlessly into older networks without media conversion.

The Ether6 also features a socket for additional storage using M-Systems DiskOnChip products, the capability of integrating a Cermetek modem modules, and is also compatible with JK microsystems extensive [illegible] of integrated peripheral boards. [illegible]nal items such as the watchdog [illegible]485 serial port capability, and [illegible] voltage regulation make the Ether6 ideal for many embedded designs.

Pricing for the Ether6 starts at $369.00, with aggressive discounts for quantity orders. Development kits, which include an Ether6 controller, AC adapter, cables, manual, and programming software are priced at only $449.00 each.

For more information, contact:

JK MICROSYSTEMS, INC.
1403 5TH ST., STE. D
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EMAIL: jkmicro@jkmicro.com
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The rockets come in two styles – straight and spiral – and can handle high acceleration, high speeds, direct "impact" recovery, and can be used repeatedly.

The rugged, lightweight launcher transports easily, and takes just minutes to assemble.

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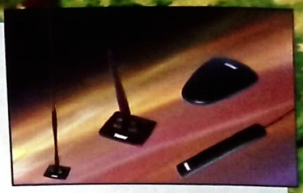

TERK Technologies has expanded their popular line of cellular car antennas.

TERK's new cellular antennas – which are designed to maximize performance of fixed-installation hands-free kits – all feature dual band frequencies for compatibility with most service providers.

The full-line of cellular antennas are dual band for PCS and AMPS frequencies and are quickly and easily mountable. All necessary parts, including 16-1/2 feet of pre-terminated coaxial cable with an FME connector and a mini-UHF adapter (depending on your style of phone) are included. Each unit, except the CFR-903, is exterior mountable, with a through-glass coupling box and cable connections on the interior of the window. Each unit is backed by TERK's three-year limited warranty and is currently shipping.

CFR-903, the most discreet of all the new TERK cellular antennas and the only inside mount unit. The CFR-903 is a mere 4 inches long and 3/4" wide. A great fit for any consumer looking for a virtually invisible antenna solution, this discreet antenna is unobtrusive and mounts vertically to any plastic or glass surface (can be mounted horizontally in strong signal areas). The CFR-903 is designed to minimize size and obtrusiveness without sacrificing performance. The MSRP is $59.95.

CFR-904, smaller than a computer mouse, with a virtually "no-profile" design. The CFR-904 antenna is exterior glass mounted and requires no removal even when entering a car wash. The CFR-904's low-profile design provides excellent performance while virtually eliminating the possibility for breakage or vandalism. The CFR-904 has an adhesive backing and can be mounted on either the center of the front or rear windshield, or in any of the windshields' corners, as close to the top of the glass as possible for optimum reception. The MSRP is $64.95.

CFR-905, built with a shorter, tapering design. The CFR-905 has a 3.5" whip which starts at a thicker base for added strength, but narrows at the top to reduce wind resistance. The CFR-905 is both side and rear-window mountable, and the whip can be unscrewed for automatic carwashes. The antenna's whip should be positioned at least 3 1/2" from any other external antenna for maximum performance. The MSRP is $64.95.

CFR-906, ideal for an SUV or minivan. The CFR-906 whip extends over 13" from the antenna footing to rise above the vehicle's roofline for optimum performance and to deliver high gain for powerful digital and analog signals, even in outlying areas. The unique tapered design of the CFR-906 offers excellent aerodynamic properties, eliminating wind noise, as well as reception problems caused by excessive antenna vibration. An exterior glass mount antenna that can be installed easily and quickly on the side or rear window, the CFR-906 can be simply unscrewed when driving through a carwash. The MSRP is $64.95.

For more information, contact:

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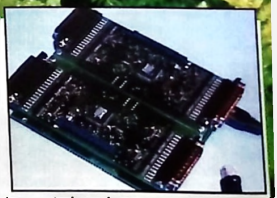
JNT-36XX OPTO INPUT MODULE



J-Works, Inc., announces the Model JNT-36XX Opto Input Module.

The Model JNT-36XX is a low-cost member of a new family of products that communicate with PCs and other computers over Ethernet and Internet networks.

It provides opto-isolated inputs that can be read in an open systems environment from any number of remote sites.

Synchronous or asynchronous client/server communication with the modules can be with socket level TCP, UDP, or HTTP protocol.

An embedded HTML control panel can be used to view the state of the inputs over the web. Input range is 0V to 30V. Several configurations of inputs up to 256 points per module are available.

The module replaces internal PC-based plug-in cards in various test, control, and measurement applications.

Complete specifications are available on J-Works website at www.j-works.com.

Single unit price for the Model JNT-36XX starts at $375.00.

For more information, contact:

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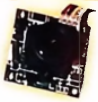

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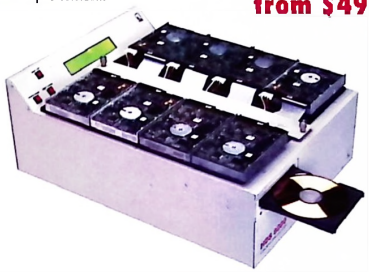

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